Report

POSAR MO34

Chapter 13 MO34 NPP environment impact evaluation

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USED ABBREVIATIONS AND DENOTATIONS

ALARA	As Low As Reasonable Achievable
AOX	Adsorbable organically bounded hologens
CED	Collective effective dose
CHWT	Chemical water treatment
CHWT	Chemical water treatment
ČR	Czech Republic
CRCS	Central Radiation Control System
ČSKAE	Commision for Atomic Energy of Czechoslovakia
CWTS	Cooling Water Treatment Station
DaKEC	Long-term and short-term environmental targets
DGS	Diesel generator station (CS 442/1-02)
EIA	Environmental Impact Assessment
EL	extractable substances
EMO	Nuclear power plant Mochovce (4 units)
EMO12	Nuclear power plant Mochovce, units 1 and 2 (in operation)
EMS	Environmental Management System
FS KRAO	Final processing of liquid radioactive waste
GJ	Gigajoule
HMG	Schedule
I.O.	Primary circuit
IAEA	International Atomic Energy Agency
IED	Individual effective dose
IHE	Institute for Hygiene and Epidemiology (Prague, ČR)
IŽP	Inspection of the Environment
JAVYS	Nuclear and Decommissioning Company, a.s., Jaslovské Bohunice
km	kilometers
KUZP	Regional authority of the environment
L&C	Technical specification of safe operation
LRKO	Laboratory for radiological monitoring in the environment CS 852/4-01,05
MDA	Minimum detectable activity
MH SR	Ministry of Economy SR

MO34	Nuclear power plant Mochovce, units 3 and 4
MP	Monitoring plan
MSVP	Intermediate spent nuclear fuel storage
MŽP SR	Ministry of the Environment of the Slovak Republic
NF	Nuclear Facility
NG	Natural gas
NPP	Nuclear power plant
NR SR	National Parliament of Slovak Republic
NRA SR	Slovak nuclear regulatory authority
NT	Low preasure
NV SR	Government regulation
OIPaK	Department of integrated authorization and control
PDE	Equivalent dose rate
PHA SR	Publil Health Authority of Slovak Republic
POSAR	Pre-operational safety report
PPDE	Ambient dose rate equivalent
PSR	Periodical Safety Report
PWT	Purification Water Treatment
RN	Radionuclide
RU RAO	National radioactive waste depository
SDS	Stable dozimetric system
SE	Slovenské elektrárne, a.s.(Slovak electricity company)
SIŽP	Slovak IŽP
SKOV	Control station of waste waters
SR	Slovak Republic
Sv	Sievert – unit of the equivalent dose (dose equivalent) or effective dose
SVP	Administrator of watercourses and drainage basins
TDS	Teledosimetry system
TJ	Terrajoule
TLD	Termoluminiscence dosimeter
TOC	Total Organic Carbon
VUJE	VUJE, Inc.
VVER	Water - water energy reactor

INTRODUCTION

The Chapter 13 of POSAR characterizes the measures and procedures accepted for monitoring, control and regulation of releasing of radioactive and non-radioactive substances (waste) into living environment (i.e. into atmosphere; surface and underground waters and; to depositories of municipal waste). Releases and leakages of the radionuclides as well as the quantities of other released pollutants must be in accordance with operational license awarded by relevant regulator offices. The Chapter was elaborated according to [II.16] and [II.17] was taken into the account in reasonable scope.

The Subchapter 13.1 describes the expected radiological influence of MO34, which was established on the basis of reference EMO12, till to now. The estimation of the real values of the radioactivity of released radionuclides from the constructed source is done on the basis of the experience from operation of EMO12 till to now as well as of other nuclear power plants of similar type. The subchapter describes the contemporary stage of radiological situation on the site and the results of monitoring of the individual components of living environment, which characterize the radiological background and the impact of operation of two units of nuclear power plant Mochovce till to now. These data are acquired due the realization of the SE-EMO environmental monitoring program (which monitors the impact of EMO12 and FS KRAO to the environment) and RURAO environmental monitoring program. The description of the monitoring systems of the SE-EMO environment and RURAO environment are assigned in the chapter 4.8 of POSAR [I.29]. The monitoring program of the SE-EMO surrounding environment describeed in this chapter will serve also for the monitoring of the MO34 impact.

The subchapter describes further the evaluation of the doses of population, calculated on the basis of estimated design-based values on activity of the released radioactive substances into atmosphere and hydrosphere during the operation of all four reactor units of EMO. These values are compared with doses from up to now operation, which were calculated on the basis of actualized model parameters and real radionuclides radioactivity in the releases from EMO12 into atmosphere and hydrosphere in years 2005 - 2014.

The subchapter - 13.2 “Non-radiological influences” – deals with evaluation of other anticipated influences. The subchapter documents the influence of the NPP operation to living environment in wider consequences. It comes out from the evaluation of the contemporary situation and from consideration of the anticipated influences regarding their significance and the time slope of the influence. The linked activities called up by the construction and operation of nuclear power plant is briefly mentioned. Such activities may cause any influences regarding the contemporary situation of the living environment on relevant site and regarding the degree of the protection of the nature, natural sources, cultural heritage etc.

The evaluation of the influence of MO34 future operation on the surrounding living environment is concerned mainly on consideration of the risk increment for population in the environment from putting of MO34 into operation to the existing risk, to which is population exposed in the consequence from the existence of NF already operated on this site - EMO12 (including the operation of the final processing of liquid radioactive waste FS KRAO and the National radioactive waste depository (RÚ RAO)). The POSAR declares that this increment is very low and that during the normal operation of MO34 the legislative limits will be not exceeded.

13 INFLUENCE OF NPP MO34 ON LIVING ENVIRONMENT

13.1 Radiological influence

The basis for evaluation of radiological influence of nuclear power plants on living environment is the monitoring and balancing of total activity of the releases of radioactive substances controlled released from NPP into atmosphere and hydrosphere. The radioactive substances may pass immediately to the individuals and whole groups of population trough atmosphere and hydrosphere and other articles of food chain in the NPP environment and; cause the external irradiation or internal irradiation of individual organs of the body. Internal irradiation occurs after radioactive substances get into body trough inhalation or ingestion.

The control of activities in gaseous effluents is carried out by continuous monitoring (aerosols, iodine and radioactive noble gases) and by balance control of gaseous releases. Balancing of released radionuclides into the atmosphere is ensured through the sampling device and subsequent laboratory analysis of taken samples. In the MO34 ventilation stack sampling systems are as follows:

- The sampling of aerosols and iodine for laboratory analysis (type VOPV-10 and type VOPV-12)
- The sampling system for a high pressure sample of radioactive noble gases (type OZ -1) for single radionuclides volume detection in the noble gaseous mixture
- The collection of ^{3}H and ^{14}C (Type V3H14C)

The regulation and control of releasing is powered by total beta analysis of samples from control tanks where the so-called over-balance waters are cumulated to be later released into water recipient. Other way, the water management is a closed system and waters other than those in control tanks may not pass into living environment.

At the outlet of waste waters into releasing pipe from EMO in the control station of the wastewaters - CS 368/1-01(SKOV) is installed continual monitor of waste waters, ensuring measurement of total gama activity of the water (by scintillation detector) and investigation and intervention levels checking of released waters out of NPP. Part of this system is device ensuring periodical sampling as well as immeadiate sampling in case of overrun of investigation and intervention levels. Radionuclides released into hydrosphere are balanced according to analyses of these average samples.

The released wastewater is dissolved with water from NPP only (blow-down from the cooling towers etc.). Wastewater released to the surface waters (the Hron River) are dissolved further with the water from the recipient, so the measurement of dissolved water is more difficult because of lower acitivities. After radiological mimnitoring the wastewaters are led directly to the Hron river help the underground pipeline system. The pipeline mouths into the river downstream from the dam in V. Kozmálovce.

The release of radionuclides into the environment is governed by strict criteria, which are based on the current legislative requirements [II.5], which are included in the Quality Requirements for Project MO34 [I.32].

13.1.1 Radioactive effluents and theirs limitation

13.1.1.1 Authorised limits and annual reference levels approved by PHA SR

According to the act [II.5] authorised limit is a quantitative indicator that is the result of optimization of the radiation protection for the given action leading to exposure, or source of ionizing radiation and that is usually lower as boundary dose; authorized limits can be de defined in permit for carrying out an action leading to exposure.

Annual reference levels of discharges are approved by PHA SR in their decision on radioactive substances release permit regarding the substances that are created during a nuclear installation operation (e.g. see the valid permit for EMO12 No. OOZPŽ/6773/2011 [I.3]). Their purpose is to limit and optimize irradiation of the population living at the surroundings of assessed individual source of ionizing radiation (e.g. nuclear installation). Within this limitation process PHA SR establish a basic radiological limit for an individual source of ionizing radiation and a representative person of the locality (for EMO12 it is 50 µSv/year) so that all the ionizing radiation sources of the specific locality don't exceed the limit dose 250 µSv/year [II.5].

13.1.1.1.1 *Annual reference levels of discharges approved by PHA SR*

The problem in evaluation of discharges and their radiological consequences to the population is that during a normal operation the NPP impact cannot be directly measured in the surroundings – even a measurement by means of doses or any other quantities is impossible. That's why the Operator has to perform a primary inspection so that the released radioactive substances activity is measured directly at the spot of release from NPP – it means, in the venting stack of NPP in case of gaseous pollutant and in the waste water channel in case of liquid discharges. Radioactive substances activity released per a specific period (a daily one, an annual one etc.) is determined as a product of the radioactive substances volume activity and the medium flow rate at the release spot. The radioactive substances are configured in radionuclides groups according to their physical, chemical and radiological properties (e.g. inert noble gases, iodines in aerosol and gaseous form with transition half time longer than 8 days, transuraniums, isotopes of strontium, 3H, 14C).

The activity of the radioactive substances released to the environment, as well as other values of quantities applied in the model of the population dose load calculation (see the chapter 7.1 of this POSAR [I.21]), are input parameters of the model that can influence the results of the population dose load calculation regarding a specific period of time. Assessment of the operation impact on the population living in the NPP surroundings can be performed only by a verified and approved model including its parameters (in the permit of PHA SR). That's why each change of the model parameters is considered as an activity important in terms of radiation protection and it is subject to review and approval of PHA SR [II.5] (see the valid permit for EMO12 [I.3]).

According to the calculations by means of an approved model, the Operator shall determine and propose such values of the discharges parameters which will assure transparent and reliable keeping the basic radiological limit for the specific source and locality. Following these values review, the PHA SR shall approve them as annual reference levels of discharges that have to be measured from time to time (and regularly, as well) by the Operator and that can't be exceeded. A violation of the limits is considered to be an administrative tort.

According to Monitoring plan for MO34 the discharge parameters for which the annual reference levels will be specified are following balance monitoring values in ventilation stack of MO34:

- a mixture of radioisotopes of noble gases,
- radioisotope of iodine -^{131}I (a sum of gaseous and aerosol form),
- a mixture of radioisotopes with transition half time longer than 8 days in the aerosols except for ^{131}I,

Regarding the waste channel (liquid discharges), the annual reference levels will be specified for:

- tritium,
- the other radionuclides (fission products and corrosion products except for tritium).

Annual reference levels of liquid discharges discharged from EMO area will be specified for conditions of surface waters of water recipient of the Hron River.

Moreover, an inspection discharges program of gaseous and liquid radioactive substance is specified in the L&C. It is necessary to assure the activity of gaseous and liquid radioactive substances discharges to the NPP surroundings during normal and abnormal operation is so that the effective dose value of a representative person of population (50 μSv/year) is not exceeded as a result of the nuclear installation operation.

All the respective requirements included in the L&C have to be monitored and met during all MODES. The discharge parameters are checked once a month. If limit value 0.05 mSv is exceeded, both units must be continuously shut down within 16 hours to MODE 3 (see L&C for MO34 [I.4], [I.5]).

13.1.1.1.2 *Reference levels for operative monitoring and control of the release process of radioactive substances*

For an operative monitoring and control of the radioactive substances release by means of venting stack discharging there are established investigation and intervention levels (reference levels) for continuously monitored discharge parameters:

- in the air pollutants released to the atmosphere for: radionuclides of noble gases an optional mixture, radioisotope of iodine ^{131}I a gaseous form, radionuclides mixture in the aerosols
- in the waste water discharges to a respective surface water recipient (the Hron River for MO34) at the boundary of EMO area: tritium and other radionuclides except for tritium.

In case an investigation level of the continually monitored quantities is exceeded, it is necessary to perform more detailed analyses and to find out the reasons. If the reasons of exceeding of continually monitored quantities of are operational or technological nature, it is necessary that measures have to be taken to eliminate them and to prevent from their repeating.

In case an intervention level of the continually monitored quantities, it is necessary to perform more detailed analyses of the discharged radioactive substances activity. If any of the parameters for which the annual reference level of discharges is established exceeds a quintuple of a daily average derived from respective annual reference level of discharges, it is necessary to find out immediately the reasons and to take corrective measures so that

- the annual reference levels of discharges and radiological limit is not exceeded and
- the principle of radiation protection optimization is demonstrably observed.

If the tritium intervention level in the waste water is exceeded, it is necessary to investigate the reasons and some measures have to be immediately taken so that

- the annual reference levels of discharges and radiological limit are not exceeded and
- the principle of radiation protection optimization is demonstrably observed,
- an impact on the population irradiation has to be assessed by means of model calculation.

In case it is not possible to perform a systematic continuous or balance monitoring of the activity or volume of the discharged radioactive substances as per a reviewed monitoring plan, it is necessary to provide for substitutional systematic sampling, substitutional measurements or any substitutional ways of the discharges activity assessment. A design of a substitutional measurement and assessment shall be submitted to PHA SR to be reviewed. The substitutional measurement and assessment system can be used only during a period necessary for elimination of the extraordinary procedure reasons or within a period established by PHA SR.

13.1.1.2 Annual reference levels of discharges for releasing of the radionuclides into living environment during the normal operation

To fulfill the above-mentioned condition (250 µSv/year) the annual reference levels of discharges for activity of radionuclides in gaseous effluents and liquid releases originally have been established in 1997, prior the commissioning of NPP Mochovce [I.2]. These limits were related to the operation of all four NPP units. They were updated for operation of two units of EMO12 (limit 50 µSv/year) after the start-up of EMO12 operation, last time in 2011, by the Decision of PHA SR in Bratislava No.: OOZPŽ/6773/2011 [I.3]. The original limits for four units as well as the limits for MO34 (Technical specification of safe opearation [I.4], [I.5]) which are equal to the actual limits for EMO12 operation are listed in the following tables.

Tab. 13-1 Annual reference level of the annual effluents

Effluents from ventilation stack	Original annual reference levels for 4 NPP units from 1997	Actual annual reference levels for EMO12 and MO34	unit
Noble gases (any mixture)	$8{,}2.10^{15}$	$4{,}1.10^{15}$	Bq/year
Iodines (^{131}I)	$2{,}4.10^{11}$	$6{,}7.10^{10}$	Bq/year
Long living particulates	$3{,}5.10^{11}$	$1{,}7.10^{11}$ (1)	Bq/year
Short living particulates	$4{,}8.10^{12}$	-	Bq/year
Strontium $^{89}Sr + ^{90}Sr$	$1{,}2.10^{9}$	-	Bq/year
Liquid effluents into the Hron river:			
Tritium	$2{,}4.10^{13}$	$1{,}2.10^{13}$	Bq/year
Other radionuclides (except tritium)	$2{,}2.\ 10^{9}$	$1{,}1.10^{9}$	Bq/year

(1) – The radionuclides with the halftime longer than 8 days are limited except ^{131}I that is limited separately. Radionuclides with halftime shorter than 8 days are not limited.

Tab. 13-2 Reference levels of the radioactivity of daily effluents to atmosphere for all operational situations

Effluents from ventilation stack	Original reference levels for 4 NPP units from 1997	Reference levels (1)	unit
Noble gases (any mixture)	$5{,}6.10^{13}$	a) $1{,}1.10^{13}$ b) $5{,}5.10^{13}$	Bq/24 hours
Iodines (^{131}I) gaseous form	$1{,}6.10^{9}$	a) $1{,}8.10^{8}$ b) $9{,}0.10^{8}$	Bq/24 hours
Long living particulates	$2{,}4.10^{9}$	a) $0{,}5.10^{9}$ (2) b) $2{,}5.10^{9}$ (2)	Bq/24 hours
Short living particulates	$3{,}3.10^{10}$	-	Bq/24 hours
Strontium $^{89}Sr + ^{90}Sr$	$8{,}2.10^{6}$	-	Bq/24 hours

(1) – Applied as reference levels: a) investigation level; b) intervention level

(2) – The mixture of radionuclides in airborne particulates is limited

Tab. 13-3 **Reference levels of the volume activity of liquid effluents**

	Original reference levels for 4 units from 1997	Reference level
	Bq/m³	
- Tritium	$2,2.10^8$	$1,0.10^8$
- Other radionuclides (activation and fission)	$4,0.10^4$	$4,0.10^4$

The annual reference levels for releasing of radionuclides from the MO34 double-unit were in principle established as one half (1/2) from the original values considered for the four-reactor-unit EMO. An exemption is the annual reference level for ^{131}I, which was restricted twice on the basis of NRA SR request. This fact is the consequence of the increasing of the quality of the monitoring. In the newest decision of the PHA SR for EMO12 (the same is supposed for MO34), the short-living airborne particulates are not limited in the releases through the ventilation stack. The reason is, that the activity of such radionuclides in the ventilation stack and such way also the radiological impact to the population are too small. On the other hand, even not limited, such radionuclides are monitored and involved in the balance sheets; the operator may adopt necessary measures. This process valid also for other radionuclides – see point 5 below. Similarly, the radionuclide ^{90}Sr is not limited but monitored (as part of the long-living radionuclides and also in the balance measurements).

The annual reference levels for MO34 were complemented with investigation and intervention reference levels. From the practical reasons, the intervention level of other radionuclides activity (except tritium) for the releases to the hydrosphere was established as the investigation level (needs the shutdown of the radionuclides release), as the investigation cannot be provided subsequently (the water streams down).

The mentioned Decision of PHA SR [I.3], which establishes the limits for release of radioactive substances into the environment, establishes also next conditions besides respecting the established of releases:

1. Irradiation of the population in EMO12 surroundings caused by releasing of radioactive subsatnces must be evaluated by calculation models. For modelling of the population irradiation caused by releasing of radioactive subsatnces during the EMO12 normal operation must be used software RDEMO. To evaluate systematically the level of radioactive effluents and to provide actions in accordance with optimisation principle of radiological protection so that:
    a. Only those radioactive substances, which is not possible separate from released media by effective manner may be released into living environment
    b. The radioactivity in the released gaseous effluents and released water into living environment; the manner and release regime shall be controlled so, that the influence of releases and exposure of the population were such low as reasonable achievable under consideration of economic and social aspects.
2. To provide evaluation of the impact of radioactive releases on the radioactivity of living environment as well as on the exposure of population in the surrounding area of the Mochovce nuclear power plant. For evaluation of radiological consequences of MO34 normal operation use calculation program RDEMO.
3. To monitor continually:
    a. Gross volume activity of the radionuclides of noble gases; gross volume activity of airborne particulates; and volume activity of isotope ^{131}I in gaseous form in the gaseous effluents,

b. Gross volume activity gamma of radionuclides in the waste waters.

4. For the reason of balancing and evaluation of exposure:
   a. In gaseous effluents, to monitor the activity of:
   - Noble gases radioisotopes ^{41}Ar, ^{85}Kr, ^{85m}Kr, ^{87}Kr, ^{88}Kr, ^{133}Xe, ^{133m}Xe a ^{135}Xe,
   - Radioisotopes in airborne particulates: ^{51}Cr, ^{54}Mn, ^{59}Fe, ^{57}Co, ^{58}Co, ^{60}Co, ^{65}Zn, ^{89}Sr, ^{90}Sr, ^{95}Zr, ^{95}Nb, ^{103}Ru, ^{106}Rh, ^{110m}Ag, ^{124}Sb, ^{134}Cs, ^{137}Cs, ^{141}Ce a ^{144}Ce, ^{238}Pu, $^{239+240}Pu$, ^{241}Am,
   - Radioisotope of Iodine ^{131}I (sum of gaseous and particulate form),
   - Tritium,
   - Radioisotope of Carbon ^{14}C in organic and inorganic forms.

   b. In released waste waters, to monitor the activity of:
   - Radionuclides ^{51}Cr, ^{54}Mn, ^{59}Fe, ^{57}Co, ^{58}Co, ^{60}Co, ^{65}Zn, ^{89}Sr, ^{90}Sr, ^{95}Zr, ^{95}Nb, ^{103}Ru, ^{106}Rh, ^{110m}Ag, ^{124}Sb, ^{131}I, ^{134}Cs, ^{137}Cs, ^{141}Ce a ^{144}Ce, ^{238}Pu, $^{239+240}Pu$, ^{241}Am,
   - Tritium.
5. In the case, other radionuclides than those listed above will be identified in the release, then involve the identified radionuclide and the measured activity into balance and evaluation of the influence of radioactive releases on the environment.
6. If the activity measured is lower than minimum detectable activity (MDA); then the value of half MDA is to be used for effluent balancing and evaluation of the impact to dose burden (in accordance with the requirement of conservative evaluations).
7. To evaluate the quantity of released effluents and the quantity of released water containing the radioactive substances.
8. The measurements of the activity of released radioactive substances for balance reasons and for evaluation of the impact to population exposure are to be provided with metrological verified measuring equipment.
9. To report to PHA SR in Bratislava:
   a) Notification on over-range of radiological limit or the annual reference levels of discharges immediately at latest until 24 hours after identification. Notification on over-range of investigation or intervention limits latest until 5 working days after identification,
   b) Report on results of investigation of the causes and consequences of the limit, the annual reference level , investigation or iontervention levels over-range until 20 working days after identification,
   c) Report on released activity of effluents and released waste water every calendar quarter until 60 days after end of calendar quarter,
   d) Report on annual balance of the activity of released radioactive substances to the atmosphere and surface water including the evaluation the impact of the effluents to the exposure of the population according point 2) until 31 March of the subsequent year.
10. Notify to PHA SR in Bratislava any changes in documentation and operational procedures that were attached to the application for the license award and on the basis of which was the license awarded.

In the L&C for MO34 operation are presented processes of the activities in the case of violation of limited conditions. After reaching or over-range of intervention level according to Tab. 13-2 in any component, such measures shall be adopted including reactor power decrease or continual shut down in to MODE 3, leading to decrease of activity of gaseous releases below the value of annual reference level condition [I.4].

In the same time, such measures shall be adopted to prevent for the over-range of the annual effluent annual reference level conditions according Tab. 13-1. Reaching or over-range of the investigation level according Tab. 13-2 in any component warns the operator, that some of the processes for releasing of the radionuclides into atmosphere trough ventilation stack do not work in accordance with design parameters. The operator is obliged to explore the causes and, to adopt measures for avoiding such process. Similarly, after reaching or over-ranging of the intervention level of volume activity of released water according Tab. 13-3 the operator is obliged to stop release immediately and, after reaching or over-ranging of the investigation level to explore the possible causes and to adopt measures for elimination of the causes. (For other radionuclides (except tritium) is valid: the intervention level = investigation level.)

Note: The determination, which reactor unit is responsible for increasing of the radionuclides activity in releases, is possible on the basis of radiological situation development in individual reactor units at least from the reaching of the investigation level of the radioactivity in the releases (both gaseous and liquid).

Fractions for the individual NF EMO from the total limits on the site are established to be warranted that the effective doses of individuals in the critical group of population in the whole surrounding area will not over-range the value of 250 μSv for one calendar year in a consequence of releasing of the radioactive substances into living environment.

In Annex 1 the fractions of the limits for gaseous and liquid effluents are assigned for the individual NF on the Mochovce site and for comparison also with the Jaslovske Bohunice site.

The clearance levels for solid RAW release are derived from the value of maximum annual allowed individual dose for the member of the critical group of persons (10 μSv.year-1) and from the total collective dose of the population (1 manSv/year) caused by released material (as it is introduced in the Act 87/2018 [II.5]).

If criteria for radioactive contamination according to release levels given in Tab. 1 of the annex No 5 in the Act No 87/2018 [II.5] are met, the above mentioned condition is considered to be fulfilled without any further proving.

The design basis related to the solid radioactive waste production at MO34 NPP considers storage capacity relevant to the annual production of 230 to 330 m^3 [I.10]. The percentage of each type of solid RAW (by volume) is the following:

a) 60% of compactable waste,
b) 30% of non-compactable waste,
c) 10% of heating, ventilation and air conditioning system filters.

Treatment process of individual radioactive waste types is described in Chapter 14 of this POSAR [I.24].

13.1.1.3 Design releases of radionuclides (releases to atmosphere, releases to hydrosphere) and releases during the normal operation

The annual reference level activities of individual radionuclides in annual discharges into atmosphere for 2 units of MO34 that are used for evaluation of radiological consequences are presented in Tab. 13-4. For evaluation of radiological consequences of effluents into hydrosphere, these activities are listed in Tab. 13-5. These values have been calculated for new fuel Gd2, with 4,87% enrichment and 6-year fuel cycle [I.21]. The calculation was carried out on basis of values measured by EMO12 (yield of particular radionuclides in annual effluents) to a annual refrence levels of effluents according to Decision of PHA SR. By intercomparison of designed effluents with measured ones (presented in Tab. 13-18, Tab. 13-19 and Tab. 13-21, Tab. 13-24), it is clear that design/projected effluents are few orders of magnitude higher. Exception in tritium which real activity in effluents is very close to estimated one.

Tab. 13-4 Designed annual effluents into atmosphere for 2 reactor units MO34 [I.21]

Nuclide	Release [Bq]	Nuclide	Release [Bq]
H 3	4,56E+11	Mo 99	3,43E+10
C 14	4,50E+11	Ru 103	1,26E+08
Na 24	1,08E+09	Ru/Rh 106	2,76E+08
Ar 41	2,82E+12	Ag 110m	1,57E+10
Cr 51	2,02E+09	Sb 122 *	1,82E+05
Mn 54	1,54E+09	Sb 124	1,03E+09
Mn 56	1,86E+10	I 131	6,70E+10
Fe 55	6,01E+09	I 132	4,13E+10
Fe 59	8,89E+08	I 133	3,15E+11
Co 57 *	6,41E+07	I 134	4,86E+10
Co 58	5,76E+09	I 135	2,08E+11
Co 60	4,23E+09	Xe 133m *	1,93E+14
Zn 65	2,65E+08	Xe 133	2,99E+15
Se 75 *	9,34E+08	Xe 135	7,11E+14
As 76 *	2,81E+07	Cs 134	7,98E+09
Kr 85m	5,95E+13	Cs 137	1,20E+10
Kr 85	5,69E+12	Ba 140	6,41E+09
Kr 87 *	3,82E+13	La 140	2,40E+10
Kr 88	1,02E+14	Ce 141	1,14E+08
Sr 89	3,81E+09	Ce 144	4,15E+08
Sr 90	2,03E+07	Hf 181 *	3,17E+08
Sr 91	6,21E+09	Pu 238 *	5,38E+05
Zr 95	6,11E+09	Pu 239 *	1,22E+06
Zr 97	9,14E+09	Pu 240 *	1,22E+06
Nb 95	9,29E+07	Am 241 *	1,11E+06
Nb 97	1,54E+09		

Note:

(1) –Three forms of Iodine are considered E-elementary(30%), O-organic (60%), A-aerosol (10%)

(2) - The effluents of nuclides ^{65}Zn, ^{103}Ru, ^{106}Ru, ^{110m}Ag, ^{124}Sb, ^{141}Ce, ^{144}Ce required in the decision of PHA SR [I.3].

** - radionuclides must be monitored in accordance with decision of PHA SR [I.3].*

Tab. 13-5 Designed annual effluents into hydrosphere for 2 reactor units MO34 [I.21]

Nuclide	Release	Nuclide	Release
H 3	1,20E+13	Ru 103 *	4,79E+06
Cr 51	1,12E+08	Rh/(Ru 106)*	1,19E+07
Mn 54	2,23E+06	Ag 110m *	5,50E+07
Mn 56	1,97E+07	Sb 124 *	9,70E+06
Fe 55	3,16E+07	I 131	3,80E+06
Fe 59	1,97E+06	I 132	4,18E+05
Co 57 *	3,68E+06	I 133	7,15E+05

Nuclide	Release
Co 58 *	2,04E+07
Co 60	3,41E+06
Zn 65 *	8,24E+06
Sr 89	8,57E+04
Sr 90	7,59E+05
Sr 91	2,79E+05
Sr 92	8,64E+06
Zr 95	2,51E+07
Zr 97	2,18E+08
Nb 95	1,22E+07
Nb 97	3,69E+07
Mo 99	3,19E+08

Nuclide	Release
I 135	2,46E+06
Cs 134	8,98E+05
Cs 137	4,04E+07
Ba 140	6,97E+07
La 140	4,34E+07
Ce 141	4,74E+06
Ce 144 *	2,87E+07
Pu 238 *	1,42E+04
Pu 239 *	5,48E+04
Pu 240 *	5,48E+04
Am 241 *	3,16E+04

Note:

* Radionuclides were measured in EMO12 effluaents or must be monitored according to the requirement of PHA SR, which is defined in decision about releases from EMO12 [I.3].

Summary of measured effluents released into atmosphere and hydrosphere in EMO12 (which is similar to the MO34) and its comparision to annual reference levels are presented in following Tab. 13-6 and Tab. 13-7. From the table is clear that aboce mentioned statement is valid.

Tab. 13-6 Intercomparisom of real effluents and annual reference levels into atmosphere for EMO12

Year	Noble gasses Annual reference level 4,1E+06 GBq		I-131 Annual reference level 6,7E+04 MBq		Aerosols Annual reference level 1,7E + 05 MBq	
	Balance [GBq]	% of annual reference level	Balance [MBq]	% of annual reference level	Balance [MBq]	% of annual reference level
1998	7.89	0.192	77.25	1.20E-01	13.62	0.008
1999	12.507	0.305	108.57	1.60E-01	24.13	0.0142
2000	14.412	0.352	56.53	8.40E-02	10.92	0.0064
2001	12.712	0.31	14.65	2.20E-02	17.77	0.0105
2002	11.419	0.279	14.93	2.20E-02	8.18	0.0048
2003	10.805	0.264	1.93	2.90E-03	12.52	0.0074
2004	3.145	0.077	2.18	3.20E-03	8.12	0.0048
2005	4.566	0.111	0.38	5.60E-04	20.53	0.0121
2006	3.061	0.075	0.43	6.40E-04	19.23	0.0113
2007	2.691	0.066	10.18	1.50E-02	10.28	0.0061
2008	1.517	0.037	0.18	2.70E-04	8.39	0.0049
2009	1.466	0.036	0.25	3.80E-04	13.62	0.008
2010	1.381	0.034	0.24	3.60E-04	11.91	0.007
2011	1 946	0,047	0,516	7,7E-04	10,11	0,0059
2012	1 693	0,042	0,279	4,2E-04	20,37	0,012
2013	1 662	0,0396	0,325	4,9E-04	9,45	0,0056
2014	1 277	0,031	0,455	6,8E-04	10,53	0,0062

Tab. 13-7 Intercomparisom of real effluents and annual reference levels into hydrosphere for EMO12

rok	Tritium Annual reference level 1,2E+04 GBq		Activation and fission products Annual reference level 1,1E + 03 MBq		Released water
	Balance [GBq]	% of annual reference level	Balance [MBq]	% of annual reference level	[m^3]
1998	1 095	9,1	29,17	2,7	24 751
1999	5 772	48,1	50,63	4,6	47 72
2000	10 4S4	87,4	57,93	5,3	53 321
2001	9 248	77,1	72,41	6,6	48 637
2002	9 130	76,1	49,36	4,5	46 620
2003	10 714	89,3	40,88	3,7	52 532
2004	9 826	8l,9	37,84	3,4	43 830
2005	8 959	74,7	59,58	5,4	40 360
2006	10 230	853	32,75	3,0	22 220
2007	7 458	62,2	13,01	1,18	21 230

rok	Tritium		Activation and fission products		Released water
	Annual reference level 1,2E+04 GBq		Annual reference level 1,1E + 03 MBq		
	Balance [GBq]	% of annual reference level	Balance [MBq]	% of annual reference level	[m^3]
2008	7 856	65,5	13,88	1,26	16 800
2009	11 450	95,4	16,84	1,53	18 650
2010	9257	77,1	13,77	1,25	24 910
2011	11 440	95,3	14,29	1,30	18 000
2012	12 130	101,1	17,77	1,62	17 790
2013	11 870	98,9	15,97	1,45	16 220
2014	10 750	89,6	11,33	1,03	18 130

From all types of released low-active and conditionally active waters, the most important from the radiological point of view are the waters with Tritium content. The radioactivity of the Tritium exceeds the volume activity of all remaining beta active radionuclides of approximate 5-decade orders in all waters released from the nuclear power plant. Despite relatively low radio-toxicity of Tritium (regarding other released isotopes) is the Tritium dominant isotope in the calculation of individual effective dose (IED) and collective effective dose (CED) resulting from the consummation of water contaminated with the releases.

Tritium contained waters are released in the controlled manner after previous radiochemistry analysis from the tanks of the condensate cleaning station. For NPP MO34, it is supposed the releasing of two control tanks with volume about 60 m^3 a week (the release velocity is one tank in 12 hours, like at EMO12). Real data about volume and activity of tritium water and other liquid affluents for EMO12 are presented in the following table (investigation levels of activity beta are listed in the table; average volume activity of tritium in 2010 is presented in the table). Additionally, the technology water is diluted according to needs, that volumic activity (evaluated in the laboratory on the basis of sampling from the relevant tank) of released water is in accordance with reference level for control station of waste water and river Hron.

Tab. 13-8 Volume and activity of liquid effluents from EMO12 in 2010

Source	Volume [m3/year]	Max. volume activity beta without Tritium [Bq/m^3]	Tritium volume activity [Bq/m^3]
Operational building	5 000	$4{,}0.10^4$	0
Turbine condensate cleaning	7 000	$2{,}0.10^4$	0
Regeneration solutions from steam generator blow-down	1 000	$2{,}0.10^4$	0
Tritium waters	12 000	$4{,}0.10^4$	$7{,}71 \times 10^8$

The liquid waste could be transported outside the EMO site in the mixtures of following types of water forms:

- Tritium waters,

- Sewage water processed in the water cleaning station,
- Neutralised wastewaters from regeneration.

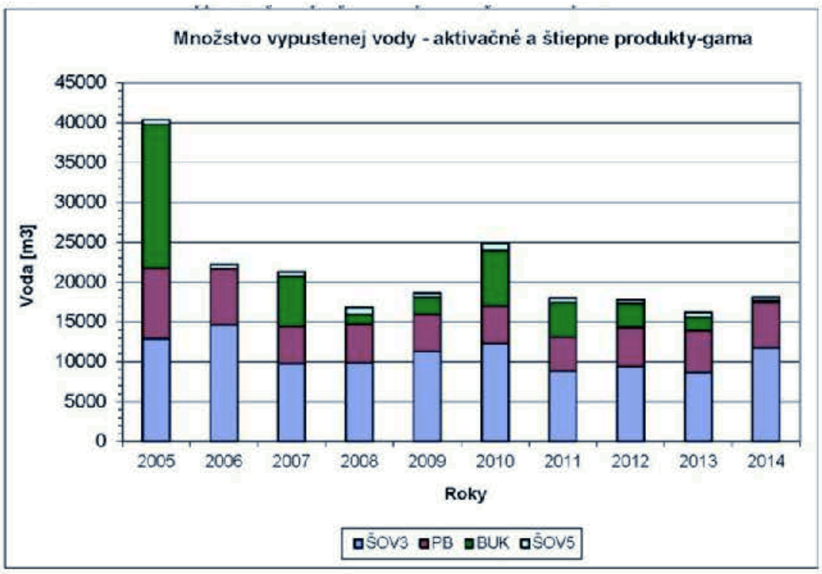

Fig. 13-1 Volume of effluents from individual sourcesin years 2005 up to 2014

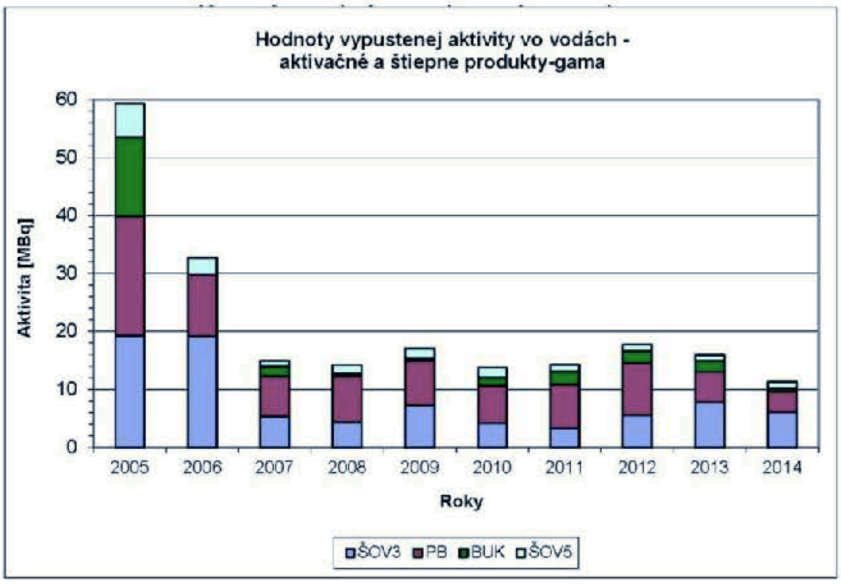

Fig. 13-2 Volume of effluents from individual sourcesin years 2005 up to 2014

Control of the liquid releases is provided by the relevant monitoring of the releases in wastewater monitoring station. The over-range of adjusted limit value will block subsequent release from the control tanks. The above mentioned wastes can get outside the NPP only controlled in the prescribed form, on schedule and in the accordance with hygiene standards. According to the LaC for MO34 [I.4] it is possible to release tritium waters from both EMO12 and MO34, because even in this situation, the intervention levels will be not exceeded.

Note: At organised release of gaseous and liquid radionuclides into surrounding environment as primary limits of activity are valid those, which are determined by corresponding sanitary supervision authority as not to be exceeded - Tab. 13-1.

The calculation of the population doses for design releases of two units of MO34 is presented in chapter 07.01 [I.21], selected results of the analysis are presented below.

13.1.2 Control of exposition of population to ionising radiation

The radiation exposure of the population in the environment of operated NF is under the normal operation such low that it is immeasurable on the background of radiological exposure from natural sources of radiation. The value of the natural radiation exposure of the population expressed in the units of effective dose is in the average 1 mSv/year without including the influence of Radon inhalation. The radiological background exposure is caused by the cosmic radiation and by the activity of surrounding living environment as the consequence of occurrence of natural radionuclides as well as in the consequence of so called “global fallout” by which the man-made radionuclides (from nuclear weapon tests, accidents of NF and other activity of man producing radionuclides) migrates in the global scale. The assessment of current radiological situation on the site is described in chapter 13.1.3.

Limit of radiation exposure of individuals of population from civilisation radiation sources is established 1 mSv/year of average effective dose on the basis of valid legislation (Act of the National Council SR No 87/2018 Coll. on Radiation protection and on changes and amendments [II.5]). This means that the existence of all civilisation sources of ionising radiation may duplicate the radiation exposure of population against background. It is permitted that the existence of one sole civilisation source of radiation (e.g. nuclear power plant) could cause only the fraction of the limit i.e. less than 1 mSv/year.

According the mentioned legislation [II.5], the limits of the exposition of individuals from population are established as follows:

a) effective dose 1 mSv in one calendar year for individual from population,

b) equivalent dose 15 mSv in the eye lens in one calendar year,

c) equivalent dose 50 mSv to skin and extremities in one calendar year,

whereby at releases of gaseous and liquid radioactive substances from NPP into the environment, on which permit of respective authority was issued, annual effective dose for representative person of population shall not exceed 0,05 mSv/year (Act No 87/2018 Coll.,[II.5], § 91, article 1)). In Act [II.5], § 91, article 2) also a boundary dose on representative person for design, construction and operation of nuclear facility is prescribed for one operator of nuclear facility and its value is 0.25 mSv per callendary year[2].

The limit value 50 µSv/year for discharge of radioactive matters is introduced among the limits and conditions for operation of 3. and 4. unit of MO34 [I.6], as well .In application for discharge permit the operator proposes annual reference levels of radioactive matters discharges, compliens of which is the guarantee of optimisation of the radiation protection on NPP. In the reality, the annual reference levels of discharges are determined by the operator very conservatively from the reason that all the details of the dissemination of radionuclides from the source to individual groups of population in the environment are not satisfactory explored.

The experience from the operation of the nuclear power plants with reactors of type VVER 440/213 in SR and ČR (2 units EMO12 NPP, 2 units EBO34 in Jaslovske Bohunice and 4 units of NPP Dukovany) show, that the real levels of activity of radionuclides in the gaseous effluents reach less than one per cent of the authorised limits – see Tab. 13-6. Similarly the real releases of the activation and fission products into hydrosphere reach level of 1 per cent from annual reference levels of discharges – see Tab. 13-7. Solely the activity of Tritium reaches the order of tens per cent (30 to 80 percent) of the authorised limits Annex 2 [III.2]. It means that in our conditions, in a consequence of low flow rates in the rivers creating the recipients, the

[2] *This boundary dose is divided to 0,2 mSv/y for atmospheric exposition pathways and to 0,05 mSv/y for hydrospheric pathways - this is why the calculated doses for particular exposure pathways are compared with these data*

hydrosphere is the critical pathway of the radiation exposure of the population (for real releases of radionuclides). The critical nuclide from point of view of drawing of annual reference levels is the Tritium - ^{3}H (in this case it causes more than 99 percents of the radiation exposure of the population trough hydrosphere – despite the fact that in generally tritium belongs to the radionuclides with lowest radio toxicity - Tab. 13-9, Tab. 13-10).

Tab. 13-9 Annual individual effective doses from designed effluents from MO34 into the atmosphere and hydrosphere for individual radionuclides and age groups in the zone 78 [Sv] [I.21]

Nuclide	0-1	1-2	2-7	7-12	12-17	Adults
H 3	1,01E-06	7,79E-07	8,97E-07	6,82E-07	5,45E-07	8,10E-07
C 14	5,94E-08	8,00E-08	8,44E-08	8,32E-08	6,79E-08	6,67E-08
Na 24	3,30E-11	3,40E-11	3,41E-11	3,38E-11	3,33E-11	3,28E-11
Ar 41	3,73E-09	3,73E-09	3,73E-09	3,73E-09	3,73E-09	3,73E-09
Cr 51	2,72E-09	2,70E-09	2,70E-09	2,69E-09	2,68E-09	2,69E-09
Mn 54	3,23E-09	3,23E-09	3,22E-09	3,21E-09	3,20E-09	3,20E-09
Mn 56	1,20E-10	1,10E-10	1,07E-10	9,77E-11	9,05E-11	1,06E-10
Fe 55	3,46E-11	4,54E-11	6,14E-11	5,73E-11	5,05E-11	9,74E-11
Fe 59	1,80E-09	1,80E-09	1,81E-09	1,80E-09	1,80E-09	1,82E-09
Co 57	1,03E-09	1,02E-09	1,02E-09	1,02E-09	1,02E-09	1,02E-09
Co 58	2,26E-08	2,26E-08	2,26E-08	2,25E-08	2,25E-08	2,25E-08
Co 60	5,45E-08	5,42E-08	5,40E-08	5,38E-08	5,37E-08	5,30E-08
Zn 65	1,91E-09	1,76E-09	1,68E-09	1,65E-09	1,56E-09	1,92E-09
As 76	2,56E-13	3,38E-13	3,35E-13	3,23E-13	2,93E-13	2,70E-13
Se 75	4,05E-10	4,10E-10	4,11E-10	4,11E-10	4,05E-10	4,03E-10
Kr 85M	1,05E-08	1,05E-08	1,05E-08	1,05E-08	1,05E-08	1,05E-08
Kr 85	1,79E-11	1,79E-11	1,79E-11	1,79E-11	1,79E-11	1,79E-11
Kr 87	2,87E-08	2,87E-08	2,87E-08	2,87E-08	2,87E-08	2,87E-08
Kr 88	2,26E-07	2,26E-07	2,26E-07	2,26E-07	2,26E-07	2,26E-07
Sr 89	9,96E-11	8,60E-11	7,10E-11	6,80E-11	6,34E-11	4,09E-11
Sr 90	9,70E-10	4,05E-10	3,41E-10	6,12E-10	8,58E-10	3,33E-10
Sr 91	2,98E-11	3,30E-11	3,27E-11	3,12E-11	2,88E-11	2,86E-11
Sr 92	1,50E-11	1,24E-11	1,17E-11	7,85E-12	5,46E-12	7,04E-12
Zr 95	6,13E-09	6,17E-09	6,19E-09	6,18E-09	6,16E-09	6,16E-09
Zr 97	6,57E-10	4,74E-10	4,49E-10	3,17E-10	2,27E-10	3,17E-10
Nb 95	2,94E-11	2,96E-11	2,98E-11	2,99E-11	3,00E-11	5,32E-11
Nb 97	5,64E-15	4,41E-15	4,33E-15	3,90E-15	3,62E-15	6,04E-12
Mo 99	4,82E-10	4,01E-10	3,85E-10	3,32E-10	2,79E-10	2,56E-10
Ru 103	1,49E-10	1,49E-10	1,49E-10	1,48E-10	1,46E-10	1,48E-10
Rh 106	2,77E-18	2,77E-18	2,77E-18	2,77E-18	2,77E-18	2,77E-18
Ag 110M	7,27E-08	7,27E-08	7,27E-08	7,25E-08	7,22E-08	7,24E-08
Sb 124	1,25E-09	1,25E-09	1,25E-09	1,25E-09	1,25E-09	1,27E-09
I 131E	6,41E-09	8,85E-09	9,97E-09	8,34E-09	7,63E-09	6,18E-09
I 131O	4,06E-09	7,89E-09	9,26E-09	6,79E-09	5,81E-09	3,66E-09

Nuclide	0-1	1-2	2-7	7-12	12-17	Adults
I 131A	1,49E-09	1,87E-09	1,91E-09	1,30E-09	9,91E-10	1,07E-09
I 132E	1,85E-10	1,98E-10	2,03E-10	1,93E-10	1,89E-10	1,83E-10
I 132O	9,20E-11	1,16E-10	1,21E-10	1,01E-10	9,61E-11	8,40E-11
I 132A	2,19E-11	2,37E-11	2,35E-11	2,18E-11	2,09E-11	2,04E-11
I 133E	5,89E-09	8,28E-09	8,59E-09	6,74E-09	6,17E-09	4,97E-09
I 133O	5,11E-09	9,04E-09	9,89E-09	6,53E-09	5,57E-09	3,60E-09
I 133A	6,77E-10	1,05E-09	1,01E-09	7,33E-10	6,03E-10	4,84E-10
I 134E	9,69E-11	1,00E-10	1,01E-10	9,97E-11	9,93E-11	9,88E-11
I 134O	6,81E-11	7,27E-11	7,39E-11	7,01E-11	6,91E-11	6,65E-11
I 134A	1,48E-11	1,54E-11	1,54E-11	1,51E-11	1,48E-11	1,46E-11
I 135E	1,96E-09	2,26E-09	2,32E-09	2,08E-09	2,02E-09	1,86E-09
I 135O	9,36E-10	1,44E-09	1,53E-09	1,11E-09	1,03E-09	7,43E-10
I 135A	2,15E-10	2,59E-10	2,52E-10	2,08E-10	1,90E-10	1,78E-10
Xe 133M	7,03E-09	7,03E-09	7,03E-09	7,03E-09	7,03E-09	7,03E-09
Xe 133	1,25E-07	1,25E-07	1,25E-07	1,25E-07	1,25E-07	1,25E-07
Xe 135	2,12E-07	2,12E-07	2,12E-07	2,12E-07	2,12E-07	2,12E-07
Cs 134	2,99E-08	3,03E-08	3,11E-08	3,28E-08	3,67E-08	3,59E-08
Cs 137	1,49E-08	1,50E-08	1,83E-08	2,58E-08	4,06E-08	4,37E-08
Ba 140	5,54E-10	3,88E-10	3,74E-10	3,27E-10	2,76E-10	2,37E-10
La 140	1,13E-09	1,17E-09	1,17E-09	1,15E-09	1,12E-09	1,14E-09
Ce 141	3,23E-10	3,22E-10	3,22E-10	3,21E-10	3,20E-10	3,21E-10
Ce 144	2,99E-09	2,94E-09	2,93E-09	2,87E-09	2,84E-09	2,88E-09
Hf 181	8,09E-11	8,25E-11	8,26E-11	8,19E-11	8,10E-11	8,04E-11
Pu 238	4,04E-11	7,45E-11	1,16E-10	1,33E-10	1,71E-10	9,41E-10
Pu 239	9,35E-11	1,75E-10	2,81E-10	3,28E-10	4,23E-10	3,63E-09
Pu 240	9,52E-11	1,77E-10	2,83E-10	3,30E-10	4,24E-10	3,63E-09
Am 241	7,99E-11	1,45E-10	2,20E-10	2,51E-10	3,29E-10	3,62E-10
Hydrosféra	1,08E-06	8,43E-07	9,59E-07	7,45E-07	6,08E-07	8,89E-07
Atmosféra	8,57E-07	8,93E-07	9,05E-07	9,02E-07	9,02E-07	8,86E-07
Suma	**1,94E-06**	1,74E-06	1,86E-06	1,65E-06	1,51E-06	1,77E-06

Note:

Zone 78 is Kalná nad Hronom (direction/sector SE, distance/annulus 7-10 km)

Tab. 13-10 Annual individual effective doses from designed effluents from MO34 into the atmosphere and hydrosphere for individual radionuclides and age groups in the zone 64 [Sv]

Nuclide	0-1	1-2	2-7	7-12	12-17	Adults
H 3	1.01E-06	7.79E-07	8.96E-07	6.82E-07	5.45E-07	8.10E-07
C 14	4.57E-08	6.16E-08	6.50E-08	6.41E-08	5.24E-08	5.14E-08
NA 24	3.03E-11	3.10E-11	3.12E-11	3.09E-11	3.05E-11	3.02E-11
AR 41	3.91E-09	3.91E-09	3.91E-09	3.91E-09	3.91E-09	3.91E-09
CR 51	2.72E-09	2.70E-09	2.70E-09	2.69E-09	2.68E-09	2.69E-09
MN 54	3.03E-09	3.02E-09	3.02E-09	3.01E-09	3.00E-09	3.00E-09

Nuclide	0-1	1-2	2-7	7-12	12-17	Adults
MN 56	1.32E-10	1.17E-10	1.14E-10	1.02E-10	9.39E-11	1.15E-10
FE 55	2.95E-11	3.81E-11	5.11E-11	4.77E-11	4.20E-11	9.05E-11
FE 59	1.76E-09	1.76E-09	1.76E-09	1.76E-09	1.76E-09	1.77E-09
CO 57	1.03E-09	1.02E-09	1.02E-09	1.02E-09	1.02E-09	1.02E-09
CO 58	2.22E-08	2.22E-08	2.22E-08	2.22E-08	2.22E-08	2.22E-08
CO 60	5.21E-08	5.18E-08	5.16E-08	5.14E-08	5.13E-08	5.07E-08
ZN 65	1.87E-09	1.72E-09	1.64E-09	1.61E-09	1.52E-09	1.89E-09
AS 76	2.20E-13	2.84E-13	2.82E-13	2.72E-13	2.49E-13	2.31E-13
SE 75	3.69E-10	3.73E-10	3.74E-10	3.74E-10	3.69E-10	3.67E-10
KR 85M	1.03E-08	1.03E-08	1.03E-08	1.03E-08	1.03E-08	1.03E-08
KR 85	1.67E-11	1.67E-11	1.67E-11	1.67E-11	1.67E-11	1.67E-11
KR 87	3.15E-08	3.15E-08	3.15E-08	3.15E-08	3.15E-08	3.15E-08
KR 88	2.28E-07	2.28E-07	2.28E-07	2.28E-07	2.28E-07	2.28E-07
SR 89	8.50E-11	7.27E-11	5.95E-11	5.66E-11	5.24E-11	3.41E-11
SR 90	9.16E-10	3.85E-10	3.22E-10	5.82E-10	8.07E-10	3.14E-10
SR 91	2.70E-11	2.95E-11	2.93E-11	2.80E-11	2.61E-11	2.59E-11
SR 92	1.97E-11	1.62E-11	1.53E-11	1.02E-11	7.13E-12	9.20E-12
ZR 95	5.87E-09	5.90E-09	5.91E-09	5.90E-09	5.89E-09	5.88E-09
ZR 97	6.75E-10	4.80E-10	4.55E-10	3.19E-10	2.28E-10	3.23E-10
NB 95	2.68E-11	2.70E-11	2.71E-11	2.72E-11	2.73E-11	5.05E-11
NB 97	6.63E-15	5.19E-15	5.09E-15	4.58E-15	4.26E-15	7.11E-12
MO 99	4.58E-10	3.70E-10	3.55E-10	3.04E-10	2.54E-10	2.34E-10
RU 103	1.47E-10	1.47E-10	1.47E-10	1.45E-10	1.44E-10	1.46E-10
RH 106	2.34E-17	2.34E-17	2.34E-17	2.34E-17	2.34E-17	2.34E-17
AG 110M	6.65E-08	6.63E-08	6.63E-08	6.61E-08	6.59E-08	6.61E-08
SB 124	1.15E-09	1.15E-09	1.15E-09	1.15E-09	1.15E-09	1.17E-09
I 131E	5.58E-09	7.56E-09	8.48E-09	7.15E-09	6.57E-09	5.39E-09
I 131O	3.11E-09	6.04E-09	7.08E-09	5.19E-09	4.45E-09	2.81E-09
I 131A	1.39E-09	1.69E-09	1.72E-09	1.15E-09	8.73E-10	9.90E-10
I 132E	1.79E-10	1.90E-10	1.95E-10	1.85E-10	1.82E-10	1.76E-10
I 132O	8.82E-11	1.08E-10	1.12E-10	9.62E-11	9.17E-11	8.15E-11
I 132A	2.17E-11	2.32E-11	2.30E-11	2.14E-11	2.06E-11	2.03E-11
I 133E	5.08E-09	7.00E-09	7.25E-09	5.76E-09	5.31E-09	4.34E-09
I 133O	3.97E-09	6.99E-09	7.65E-09	5.06E-09	4.32E-09	2.80E-09
I 133A	5.66E-10	8.58E-10	8.24E-10	6.02E-10	5.00E-10	4.09E-10
I 134E	1.04E-10	1.07E-10	1.08E-10	1.06E-10	1.06E-10	1.06E-10
I 134O	7.81E-11	8.25E-11	8.36E-11	8.00E-11	7.90E-11	7.65E-11
I 134A	1.65E-11	1.71E-11	1.71E-11	1.68E-11	1.65E-11	1.63E-11
I 135E	1.79E-09	2.03E-09	2.09E-09	1.89E-09	1.83E-09	1.71E-09
I 135O	7.84E-10	1.18E-09	1.25E-09	9.24E-10	8.61E-10	6.32E-10
I 135A	1.99E-10	2.33E-10	2.27E-10	1.88E-10	1.72E-10	1.64E-10
XE 133M	6.56E-09	6.56E-09	6.56E-09	6.56E-09	6.56E-09	6.56E-09
XE 133	1.16E-07	1.16E-07	1.16E-07	1.16E-07	1.16E-07	1.16E-07

Nuclide	0-1	1-2	2-7	7-12	12-17	Adults
XE 135	2.02E-07	2.02E-07	2.02E-07	2.02E-07	2.02E-07	2.02E-07
CS 134	2.74E-08	2.77E-08	2.85E-08	3.00E-08	3.35E-08	3.29E-08
CS 137	1.37E-08	1.38E-08	1.68E-08	2.37E-08	3.72E-08	4.08E-08
BA 140	5.26E-10	3.57E-10	3.45E-10	2.98E-10	2.49E-10	2.15E-10
LA 140	1.03E-09	1.06E-09	1.05E-09	1.04E-09	1.01E-09	1.04E-09
CE 141	3.23E-10	3.21E-10	3.21E-10	3.20E-10	3.20E-10	3.21E-10
CE 144	2.98E-09	2.91E-09	2.91E-09	2.84E-09	2.81E-09	2.86E-09
HF 181	7.35E-11	7.47E-11	7.48E-11	7.42E-11	7.35E-11	7.30E-11
PU 238	3.24E-11	5.96E-11	9.26E-11	1.06E-10	1.36E-10	9.04E-10
PU 239	7.49E-11	1.40E-10	2.25E-10	2.62E-10	3.37E-10	3.54E-09
PU 240	7.66E-11	1.42E-10	2.26E-10	2.64E-10	3.39E-10	3.54E-09
AM 241	6.44E-11	1.16E-10	1.76E-10	2.01E-10	2.63E-10	2.92E-10
Atmosféra	1.08E-06	8.43E-07	9.59E-07	7.45E-07	6.08E-07	8.89E-07
Hydrosféra	8.11E-07	8.38E-07	8.48E-07	8.47E-07	8.49E-07	8.36E-07
SUMA	**1.89E-06**	1.68E-06	1.81E-06	1.59E-06	1.46E-06	1.72E-06

Note:
Zone 64 is Nový Tekov (direction/sector ESE, distance/annulus 3 - 5 km), Table is output from RDEMO software from design analysis for chapter 07.01.

13.1.2.1 Radiological consequence of designed/reference releases and their comparison to releases during the normal operation

For the evaluation of the radiological consequences of the release of the radioactive substances (into atmosphere via ventilation stack of EMO and into hydrosphere – surface waters i.e. to the Hron River) during normal operation, the computer program package RDEMO was used. The description of calculation modelfor influence of normal operation on the population in a NPP surrounding is described in more details in Chapter 07.01 of this POSAR [I.21].

13.1.2.1.1 *Computation of the population exposure for annual refrence levels of releases of radioactive substances into the living environment*

From the application of mentioned procedures used for calculation of radiological exposure of population from the normal operation of 2 reactor units of MO34 with new nuclear fuel – the design based releases (chapter 13.1.1.3), realized in the frame MO34 POSAR chapter 07.01 [I.21], it is possible to derive the following conclusions:

a) From the results of calculations of radiological consequences of discharges into the atmosphere it follows that a way with the largest contribution to exposure from the atmosphere is external exposure from the plume which represents 68 - 72 % portion to the individual effective dose, and a not negligible contribution is about 16% from the deposit and the contribution of ingestion of food contaminated by atmospheric fallout is 9 - 12%.

   Critical nuclides are noble gases, namely ^{88}Kr, ^{135}Xe and ^{133}Xe and an non-negligible contributors are also ^{14}C and ^{110m}Ag.

b) From the results of calculations of radiological consequences of discharges into the hydrosphere it follows that a way with the largest contribution to exposure from the hydrosphere is internal exposure from the water ingestion, which represents app 77-86 % portion to the individual effective dose. Critical nuclide for hydrosphere is ^{3}H, whose contribution to annual effective individual dose from hydrosphere is up to 90 % strength.

c) Critical group from evaluation of the total impact caused by releases to the atmosphere and hydrosphere together is the population of village Kalná nad Hronom (zone No 78 - see Fig. 13-3, South-East of EMO, distance 7-10 km).

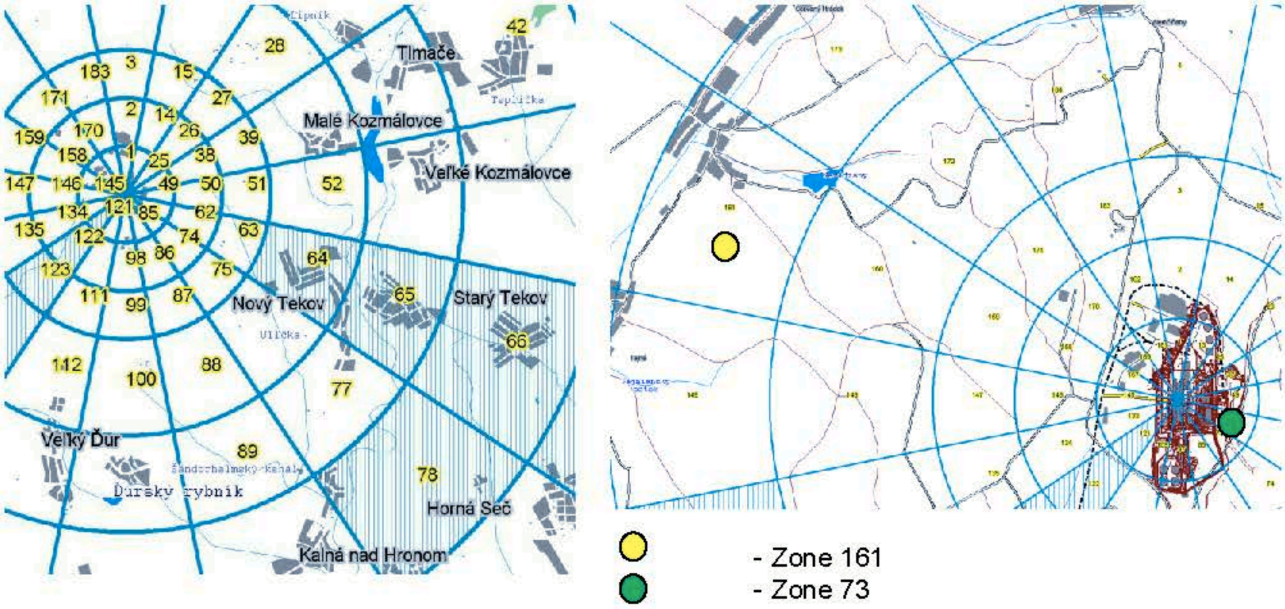

Fig. 13-3 Distribution of region into zones

The critical (maximum) values of individual effective doses calculated according to designed (guidance) values of effluents were determined for zone 78 (village Kalná nad Hronom). Comparison of IED in zone 78 with valid limits for public exposure in surroundings is listed in the following Tab. 13-11. For comparison, in Tab. 13-14 are presented calculated (according to designed values of effluents) values of IED for zone 64 (Nový Tekov), which is critical zone from point of view of real effluents.

Tab. 13-11 Values of effective doses in the zone No 78 (Kalná nad Hronom) calculated for designed releases of radioactive substances from MO34 into atmosphere and hydrosphere

Age group	Effective dose [mSv]	Fraction of the limit 1 mSv (limit for the population)	Fraction of the limit 0,25 mSv (limit for the whole nuclear site)	Fraction of the limit 0,05 mSv (radiological target for MO34)
0 – 1	1,94E-06	515	129	26
1 – 2	1,74E-06	575	144	29
2 – 7	1,86E-06	538	134	27
7 – 12	1,65E-06	606	152	30
12 – 17	1,51E-06	662	166	33
Adults	1,77E-06	565	141	28

Tab. 13-12 Values of effective doses in the zone 64 (Nový Tekov) calculated for design releases of radioactive substances from MO34 into atmosphere and hydrosphere

Age group	Effective dose [mSv]	Fraction of the limit 1 mSv (limit for the population)	Fraction of the limit 0,25 mSv (limit for the whole nuclear site)	Fraction of the limit 0,05 mSv (radiological target for MO34)
0 - 1	1.89E-06	529	132	26
1 - 2	1.68E-06	595	149	30
2 - 7	1.81E-06	552	138	28
7 – 12	1.59E-06	629	157	31
12 – 17	1.46E-06	685	171	34
Adults	1.72E-06	581	145	29

All calculated values of individual doses from design-based values of releases from MO34 (2x440 MW) under normal operation are lower than 0,05 mSv - the target value of the acceptance criteria for the MO34 design [I.6] as well as exposure limits according to the Act 87/2018 Coll. [II.5]. Radiological consequences of the releases during the normal operation are one order of magnitude lower, what is clear from comparision to calculations presented in chapter 13.1.4.4 - Tab. 13-27.

NOTE: *As the critical group of population depends from the exposition pathway, the separate critical groups for atmospheric pathway and hydrosphere pathway respectively were established as the support categories. It is clear, that the real critical group of the total releases may vary according the ratio between gaseous and liquid effluents.*

13.1.3 Monitoring program of surroundings at Mochovce site

13.1.3.1 Legislative requirements and recommendations

In accordance with UJD SR Decree Nr. 33/2012 Coll. “on periodical evaluation of nuclear safety” [II.3] it is expected that the license holder shall establish such range of the monitoring around nuclear facility to ensure the sufficiently effective surveillance program on the influence of NPP to the environment regarding the concentration of radionuclides in air, water, soil, and in agricultural products.

The functioning surveillance program according to cited decree [II.3] and to first experience with evaluation of such program means:

- The realisation of sufficiently extensive monitoring system, and the operation of a complex monitoring program of the NPP site and surrounding environment for acquisition of radiological characteristics including the continuous monitoring of selected indicative quantities (dose rate, summary beta activity of particulates) and radionuclides in individual components of the living environment (airborne particulates, deposit, food chains, surface waters, ground sediments and near bank sediments of influenced water sources).
- Building of a system of the reference data on radiological characteristics of the NPP site and the surrounding environment and individual components of the living environment.

- Building of a functional system of corrective measures in case of the exceeding of the predefined reference levels.

In accordance with the NRA SR decree [II.3] the efficiency of the established surveillance program is to be considered periodically and evaluated regularly after 10 years of NPP operation. An effective program is a condition for NPP operation license renewal.

The Act of NR SR 87/2018 Coll. [II.5] require from the operational license holder (concerning the activities that lead to exposure to ionising radiation) to create an efficient monitoring program on the site and at the NPP's neighbourhood, which shall take into account the workplace characteristics (including its surrounding), production of sources of ionising radiation and method of releasing the RAL into the environment, and it is a condition for issuing by PHA SR a decision on commencement of NPP operation.

The requirements of PHA SR and NRA SR are in accordance with IAEA recommendations "Safety requirements" NPP's safety – operation [II.6], according to which the strategy of monitoring the NPP's neibourghood shall be chosen in such a way as to allow:

- an early identification of deviation from normal operation and possible exposure of the population (or workers),
- ensuring the early undertaking of the protective and corrective measures,
- data collection for specification appropriate reference levels and proof of radiation protection optimisation (Act of NR SR 87/2018 Coll. [II.5]).

In case of accident monitoring the national and international aspects shall be considered (note: from an international point of view it is acquiring and passing information on possible spreading of contamination into another country. This is ensured by the regulator - NRA SR.

The monitoring in legislation of SR as well as in IAEA recommendations is different depending on the period, when it is carried on Preoperational and Operational. In different phases of operation of installation monitoring plan (MP) fulfils different basic aims.

- The aim of pre-operation MP is determination of parameters of background radiation situation and from that resulting reference levels of measured data for the monitoring plan (MP) before NPP commission and parameters of radiological models used for the evaluation of the site,
- The aim of operational MP is detection of deviations of the parameters of radiation situation compared to reference data and detection whether it is due to the impact of NPP operation. It also serves to continuous fine-tuning of the reference data obtained by the monitoring results.

Meaning and scope of pre-operation and operational monitoring of radiological parameters is described below.

13.1.3.1.1 *Preoperational monitoring*

The preoperational monitoring of surroundings should be generally focused to detect:

- Typical gamma radiation levels and radionuclides in environmental components of the surroundings area, including their variability,
- Specific local parameters including non-radiological (e.g. meteorological, hydrological, and demographic data input to the models, ...) that may affect:
    - Evaluation of spreading and exposure routes of RL,
    - The dose burden of the population during normal operation,

- Radiological impacts of emergency releases of RAL to nuclear facilities surroundings.

The recommendations of the IAEA, e.g. on sources monitoring in surroundings [II.7], contain more detailed objectives and the importance of monitoring during these periods as follows. Aim of the preoperational studies is to determine the basic background level of radiation and radionuclide activities in the surrounding to enable determination of the source influence during operation (NPP).

The pre-operational programme should be initiated in good time (2–3 years) before the commencement of operation so as to be able to study the annual variability in the local environment [II.7]. In case MO34 the 5 years' time period 2005 – 2010 was selected for purpose of preoperational (PP) measurements evaluation [I.22] because it fulfills the IAEA recommendations and takes into the account the data obtaining within EMO12 monitoring plane.

No requirement for commence, content or range of pre-operational studies before commence of nuclear instalation is speciefied in legislation of the Slovak Republic.

13.1.3.1.2 *Requirements on the scope of operational monitoring*

According to IAEA Safety Guide RS-G-1 [II.7], as well as to Act NR SR No 87/2018 Coll. [II.5] the monitoring in surrounding of NF according to MP is aimed at the following main goals:

a) to verify compliance with authorised release limits,

b) to provide information and data for evaluation the doses to population,

c) to check operational conditions and adequacy of monitoring characteristics of releases and to provide a warning at unusual operational conditions or initialise a special MP in the surrounding.

Apart from that, MP usually fulfils some other goals:

a) to keep continuous record on impact of operation on radionuclide levels in surrounding,

b) to check predictions of environmental models of spreading radioactive substances during exceptional releases to enable their application in evaluation of radiological impact and also to reduce uncertainty of dose evaluation.

The monitoring of a surrounding according to these recommendations is always specific to particular site. It has to be carried on in such a way as to register the changes in long-term radionuclide concentrations and directional dose rate equivalent (PPDE) in the surroundings.

In early operational phase frequent and detailed measurements are needed according to [II.6] to confirm the expected occurrences and transfer of radionuclides in the surrounding environment. After acquiring some experience it will be possible to reduce the extent of monitoring releases and the surroundings.

The monitoring and corresponding measurements shall be oriented on all types of radiation (gamma radiation is the dominant one) and on all components of the environment (particulates, atmospheric fallout, soil, surface and potable water, snow, vegetation, food chains). The PPDE is monitored as parameter of external gamma radiation.

Apart from the direct measurements of exposure paths it is recommended to consider the measurement of suitable indicating organisms. These could provide information on trends of changes in activities of radionuclides in the environment.

In components of the environment, the following parameters are measured:

- radionuclides emit gama radiation (gamaspectrometric analysys), e.g. ^{137}Cs and measurable natural radionuclides (^{40}K, U-,Th- series) in all components of the environment,

- ^{7}Be – in airborne particulates,
- ^{90}Sr and measurable isotopes of Pu and Am - in selected components, or in combined samples,
- ^{3}H –in surface and ground waters, in snow,
- ^{14}C in selected components (e.g. food chains, grass, waters),
- in addition, PPDE and PDE are monitored as specific parameters for NPP surroundings.

The places of measurements and sampling, according to the recommendations, shall represent the specifics of particular site with the aim to determine maximal doses to population and to identify potentially the most contaminated places.

Moreover, according to NV SR No. 96/2018 Coll. on the details of operation of radiation monitoring network [II.8], laboratory group LRKO is delegated by the MH SR (central authority) as a member of the permanent component of radiation monitoring grid. The permanent component of radiation monitoring grid monitors continuously according to its MP.

Measurement sensitivity shall be adequate to the objectives pursued. Trending of radioactivity in the environmental components requires very low measurement sensitivity.

From the philosophy of PSR it appears that the measurement should be provided at least in selected samples, or locations (e.g. ^{137}Cs in aerosols in the pooled sample with an appropriate volume of the atmospheric air) to allow to monitor variation and trends of radioactivity in components of the environment.

Monitoring the deviations from the reference state of background even at low levels enables a timely response on trajectory detection of unauthorised leakages at normal state or on abnormal conditions at NPP, because public awareness in case of recognition of new external source (e.g. Fukushima NPP) may be important.

The required scope of monitoring the environmental components and frequency of measurements according to [II.7] are listed in the Tab. 13-13.

Tab. 13-13 Scope of operational monitoring according to [II.7]

Discharge	Monitored constituents	Frequency
Airborne	External radiation	
	Gamma dose rate	Continuously
	Gamma dose – integrated	Twice a year
	Neutron dose rate (if neutron radiation is foreseen)	Continuously
	Neutron integrated (if neutron radiation is foreseen)	Twice a year
	Air, deposition	
	Air	Continuous collection, weakly to monthly measurement
	Rain	Continuous collection, monthly measurement
	Deposition	Continuous collection, monthly measurement
	Soil	Once a year
	Foodstuff and/or ingestion	

Discharge	Monitored constituents	Frequency
	Leafy vegetables	Each month during growing season
	Other vegetables and fruits	Selected sample, at harvest
	Grain	Selected sample, at harvest
	Milk	Each month when cows are on pasture
	Meat	Selected samples, twice a year
	Drinking water and/or groundwater	Twice a year
	Terrestrial indicators	
	Grass	Each month when cattle are on pasture
	Lichen, mosses, mushrooms	Selected samples, once a year
Hydrosphere	Aquatic dispersion	
	Surface water	Continuous sampling, monthly measurement
	Sediment	Once a year
	Aquatic foodstuffs	
	Fish	Selected samples, once a year
	Shellfish	Selected samples, once a year
	Aquatic indicators	
	Seaweeds, marine sponges	Selected samples, twice a year
	Benthic animals	Selected samples, twice a year

13.1.3.1.3 *Determination of the deviation from normal background state in the frame of operational monitoring plan*

According to the IAEA recommendation NS-G-2.10 (Periodic Safety Review of NPP) [II.9], as well as NRA SR decree No 33/2012 Coll. On periodic assessment of NPP [II.3] the normal operation of a nuclear power plant should not cause any measurable increasing of the content of radionuclides in the components of the environment (the concentrations of radionuclides in air, water, soil, agricultural and marine products and animals), which share on the important exposure pathways of the population in NPP environment. In contrary, every recorded increase shall be satisfactorily explained e.g. by specific local conditions, by external influences and events, by uncertainty of measurement etc.

It is therefore a systematic comparison of the measured values with the reference level of the background, which was determined in the previous period with sufficient series of measurements. Due to expected statistical or systematic variance in the evaluation of the measured data the use of appropriate statistical methods are expected.

The monitoring of radiation characteristics and content of RN in environmental components of the site and NPP surroundings is to be carried out to the extent possible, so as to continuously acquire sets of values to refine the benchmarks used to assess the elevation of the measured values compared to normal background levels [II.5].

13.1.3.2 Monitoring plan of Mochovce surroundings

The scope of any follow-up program should be focused on providing information needed to verify EIA predictions and mitigation effectiveness, particularly as related to likely effects carried into the significance determination step in the assessment process. Follow-up studies and monitoring should be focused on specific effect hypotheses. This would allow results to be evaluated and any appropriate corrective action to be taken in a timely manner.

The aim of the monitoring program is to describe the acitvities, to acquire environmental radioactivity data in the EMO NPP vicinity and control of influence of EMO NPP on the vicinity is ensured with these data during the operational monitoring.

Monitoring program of the NPP EMO vicinity includes technical means [I.29], operational procedures and monitoring plan [I.14] determining the extent of the systematic control of the NPP surruonding radiation situation.

The system of the monitoring of the locality using local means of EMO NPP and activities according to the approved monitoring program is described in the POSAR chapter 4.8 [I.29]. Monitoring of the surroundings is executed according to the Monitoring plan [I.14], which is approved by National Health Authority in accordance with the Act 87/2018 Coll. [II.5].

Monitoring system of NPP EMO surrounding environment consists of:

- Teledosimetry system,
- Portable devices for dose rate measurements of gamma radiation
- TLD grid in the surroundings,
- Portable means of emergency monitoring
- Sampling of the environment, treatment and evaluation in the laboratory.

For evaluation of effective dose of the population in EMO surroundings validated RDEMO software is used [I.18].

13.1.3.2.1 *Teledosimetry system (TDS)*

TDS serves for continual monitoring of radiation situation at EMO site and its surroundings during normal operation as well as during emergency situations defined in the On-site emergency plan EMO [I.52], which are linked with leakage of artificial radionuclides into the environment. TDS is designed for monitoring and quick signalization of deviation from normal conditions. Placement of TDS is presented in Annex 3.

Detection of immediate deviations is ensured in TDS by:

- Continual monitoring of dose rates,
- Measurement of aerosols and iodine activity in the airand
- Airborne sampling in case of exceeding of dose rate reference levels.

Continual monitoring of gamma radiation through TDS is an important part of the continual radiation monitoring around the operated sources. At each place is different level and variability of radiation backgrounf and therefore investigation levels are defined for each place separaley. The given levels of PPDE are on the permanent locations around EMO (40 locations) in the interval 70 to 100 nSv/h [I.13], [I.22]. The typical standard deviation of the individual 10 min. measurements on the given location is 5 nSv/h. The investigation level of PPDE in the continually monitored places (40 locations) is around 110 to 150 nSv/h. TDS includes measurement of aerosols activity and iodine activity as well.

Continuous monitoring of total beta activity of particulates and iodines directly indicates the contamination of air by these radioactive materials (for the contamination with radioactive rare gasses their detection effectiveness is negligible, e.g. they can on the given place only distinguish between contamination through radioactive rare gasses and aerosols). They are activated either automatically from the dose rate, or manually.

Measurement and sampling of aerosols and iodide in the air serves for the evaluation of the RaS in an early stage of an accident. It is very important to take timely emergency measures in order to reduce the impact of an accident on the population.

TDS system as whole is operating continuously. Informationns from TDS are transferred to the centralized computer of radiation control system.

13.1.3.2.2 *TLD Monitoring grid*

TLD Monitoring grid is used to detection the integral dose and consequently to determination the average PPDE and dose rate of 74 chosen measurement points around EMO [I.7], [I.13], [I.22]. The exchange of TLD dosimeters is carried out once per month. The investigation levels of PPDE in the locations monitored by TLD's are similar as in the places of continual monitoring (110 to 150 nSv/h).

In case of emergency situation, frequency of TLD exchange is adjusted according to the needs. More detailed description and placement of TLD is described in [I.14].

In case it is needed the TLD dosimetric system is used for personal monitoring of the population around EMO, for example during accidents. In such cases in the scope of emergency monitoring, teams of EMO specialists organize the assembly and exchange of TLD dosimeters according to the emergency monitoring procedures. A more detailed description can be found in chap. 12 "Emergency preparedness" of this POSAR [I.23].

13.1.3.2.3 *Mobile means for monitoring of EMO surroundings*

Mobile laboartories are used for these purposes. Sapling is performed by specialized tools according to the procedures listed in Program of radiation control of the NPP EMO surroundings [I.15]. These tools are part of the alignment of mobile laboratories (monitoring cars).

Dose rate is possible to be measured in motion in cars. Equipment of the laboratory also allows measuring the activity of environmental samples taken directly into the mobile laboratory.

The main goal of the monitoring cars during and after the emergency situation is very soon monitoring of the environment contamination and dose rates. Next goal is to verify the predicted spreading of the contamination.

13.1.3.2.4 *Sampling and laboratory analysis of samples from the environment at LRKO and TDS*

Sampling is performed in accordance with approved operational instruction. The following samplings are sampled in EMO surroundings: aerosols, fallouts, waters (surface, drinking, underground), sediments, soil, milk, grass, agricultural products (forage plants, vegetables and fruits) and fish. During the sampling is applied principle that sampling is performed regularly from all 16 sectors of EMO surroundings and at least two samples from each sector are taken. An important component of the monitoring is implemented system of quality assurance (evidence of samples and results of the monitoring).

Anylysis of samples are ensured by a gamma spectrometer and through radiochemical analyses according to the valid MP [I.14]. They indicate the rise of the long-term levels of RN in the environment. This way of monitoring belongs to the absolutely most sensitive measurements it is also useful for registering of trends of RN content in the environment. Because of high sinsitivities of measurements, it is necessary to measure larger volume of sample and it is necessary to acquire spectra for a long time. Disadvatage of gammaspectrometry is that results of measurements are not available immediately.

Semiconductor gamma spectrometry is an irreplaceable method for analysis of samples in emergency conditions, where a lot of short and long living radionuclides must be distinguished in a very complex RN spectrum. It concerns both early phase and later phases of monitoring.

In [I.13] is presented scope of the EMO12 surroundings monitoring in 2010 according to the "Programm of radiation monitoring of EMO surrounding" [I.15], which is yearly updated. By comparison of the table with scope of monitoring recommended by IAEA [II.7] it sollows that applied scope of monitoring is on required level.

Scope of operational monitoring of EMO is presented in Tab. 13-14, which is taken from [I.15]. Presented data are in accordance with data in "Evaluation of preoperational monitoring of the vicinity" [I.22].

Tab. 13-14 Range of the operational monitoring in MO34 surrounding in 2010 - Report of EMO12 for 2010 [I.13]

Monitored component of the environment	Measured quantity	Number of sampling/measurement points	Analyses/measurements rate	Planned number of analyses in 2010	Realized number in 2010
Dose equivalent rate - IC	Dose equivalent rate of radiation in air	15	Monthly	180	180
Dose equivalent rate - IC (Dam V.Kozmálovce)	Dose equivalent rate of radiation in air	1	Annually	1	1
Dose equivalent rate - IC (locality IN SITU)	Dose equivalent rate of radiation in air	6	Annually	6	8
Dose equivalent rate - TLD	Dose equivalent rate of radiation in air	21	Monthly	252	252
Dose equivalent rate - TLD (emergency)	Dose equivalent rate of radiation in air	50	3 times per year	150	150
Dose equivalent rate - TDS	Dose equivalent rate of radiation in air	39	Monthly	468	468
Particulates	Gamma-spectrometry	15	Weekly	780	810
	Strontium	2	Monthly	24	24
SDS Fallouts	Gamma-spectrometry	15	Quarterly	60	60
Soil (4 x SDS)	Gamma-spectrometry	4	Semi-annually	8	8
	Strontium	4	Annually	4	4
Sediments	Gamma-spectrometry	6	Quarterly	24	23
	Strontium	6	Annually	6	6
	Alpha-spectrometry	1	Annually	1	1
Surface water	Gamma-spectrometry	8	Quarterly	32	32
	Strontium	8	Quarterly	32	32
	Tritium	8	Quarterly	32	32
	^{14}C	1	Annually	1	1
	Alpha-spectrometry	2	Annually	2	2
	Gross beta activity	2	Quarterly	8	8
	Gross alpha activity	2	Quarterly	8	8
Potable water	Gamma-spectrometry	5	Quarterly	32	20
	Strontium	5	Quarterly	32	20
	Tritium	5	Quarterly	32	20

Monitored component of the environment	Measured quantity	Number of sampling/measurement points	Analyses/measurements rate	Planned number of analyses in 2010	Realized number in 2010
Ground water (sewage pipes)	Strontium	17	Semi-annually	34	32
	Tritium	17	Semi-annually	34	32
	Gamma-spectrometry	17	Semi-annually	34	32
RM borehole (SE EMO)	Strontium	1	Semi-annually	2	2
	Tritium	6	Semi-annually	12	12
	Gamma-spectrometry	6	Semi-annually	12	12
Food chain elements	Strontium	16	Annually	16	16
	^{14}C	2	Annually	2	4
	Gamma-spectrometry	16	Annually	Min 32	49
Milk	Strontium	1	Monthly	12	123
	^{14}C	1	Annually	2	1
	Gamma-spectrometry	1	Weekly	52	52
Fish	Strontium	-	Annually	1	1
	Gamma-spectrometry	-	Annually	2 - 4	4
Meat	Strontium	1	Annually	1	1
	Gamma-spectrometry	1	Annually	1	1
Snow	Strontium	1	Max 3 times per year	Max 3	3
	Tritium	1	Max 3 times per year	Max 3	3
	Gamma-spectrometry	1	Max 8 times per year	Max 8	9
IN SITU Measurement	Gamma-spectrometry	6	Annually	6	8
Soil IN SITU	Gamma-spectrometry	6	Annually	18	24
	Strontium	6	Annually	6	6
Grass IN SITU	Gamma-spectrometry	6	Annually	6	8
Soil Alpha-spectrometry	Alpha-spectrometry	2	Annually	2	2
Water plants	^{14}C	1	Annually	1	0
	Gamma-spectrometry	3	Annually	3	0
Samples from ventilation stack	^{14}C	1	2 samples every fortnight	52	47
Dose equivalent rate - TLD (RÚ RAO)	Dose equivalent rate of radiation in air	5	Monthly	60	60
Dose equivalent rate - TDS (RÚ RAO)	Dose equivalent rate of radiation in air	1	Monthly	12	12
Dose equivalent rate – IC (RÚ RAO)	Dose equivalent rate of radiation in air	5	Monthly	60	60
SDS fallout (RÚ RAO)	Gamma-spectrometry	1	Quarterly	4	4
Ground water (RÚ RAO boreholes)	Gamma-spectrometry	6	Quarterly	24	24
	Strontium	1	Quarterly	4	4

Monitored component of the environment	Measured quantity	Number of sampling/measurement points	Analyses/measurements rate	Planned number of analyses in 2010	Realized number in 2010
	Tritium	6	Quarterly	24	24
Surface water (RÚ RAO)	Strontium	1	Quarterly	4	4
	Tritium	1	Quarterly	4	4
	Alpha-spectrometry	1	Annually	1	1
	Gamma-spectrometry	1	Quarterly	4	4
Sediments (RÚ RAO)	Strontium	1	Annually	1	1
	Gamma-spectrometry	1	Quarterly	4	4
Soil (RÚ RAO)	Strontium	4	Annually	4	4
	Gamma-spectrometry	4	Semi-annually	8	8
Grass (RÚ RAO)	Gamma-spectrometry	4	Semi-annually	8	8
Dose equivalent rate - TLD (FS KRAO)	Dose equivalent rate of radiation in air	3	Monthly	36	36
Dose equivalent rate - IC (FS KRAO)	Dose equivalent rate of radiation in air	1	Monthly	12	12
Total for 2010				2808	2817

13.1.3.2.5 *Processing and storage of the results of measurement and analyses*

All monitoring results are stored in the basic database and the results are compared with the precedent results as well as with NPP operational data. All monitoring results are compared with investigation levels and are recorded in a form of electronic and print records and reports.

When determining the deviation, the measurement results of the relevant place are statistically compared with relevant background levels. This is given by the average set of background data for the last two years. To decide if the measured deviation is statistically significant is used a statistical test. If there is a deviation of ^{137}Cs (^{137}Cs is single long-term measurable RN) in particular environment component, crutial in determing whether the impact of NPP is the presence of the other RN typical for operational or accidental releases from NPP (MO34 or even EMO12). Recognizing the impact of external sources of contamination according RN composition is described in chapter 4.8 of this POSAR [I.29].

The samples are also stored in the sample storage room. The activity of radionuclides in samples emitting gamma radiation is being determined by semiconductor gamma-spectrometry analysis.

13.1.3.3 Evaluation of radiation situation at Mochovce site

In order to be possible evaluate the radiological on the site situation reliable after the putting into operation of nuclear power plant or other NF on the site, it is necessary to monitor in detail the surrounding environment of NF at least 1 year before the start-up of the first NF on the site. This requirement in the case of EMO is fulfilled with significant reserve as the first results from LRKO Levice measurement are from the period after Chernobyl accident in 1986.

The general radiological situation on the Mochovce site before the start-up of nuclear power plants and RÚ RAO (i.e. the radiological background) is characterized by:

- Level of external radiation
- Occurrence of radionuclides (with accent to man-made radionuclides) in to individual components of living environment:
    a. In the ground layer of the atmosphere,
    b. In the soil,
    c. In the surface and underground waters,
    d. In fodder and other agricultural products (foodstuffs).

13.1.3.3.1 *External radiation*

The total level of the radiation from external sources is the quantity integrating the individual components of the external radiation, mainly:

- Cosmic radiation given by the attitude of the measurement place above the sea level,
- Terrestrial radiation given by the activity of natural and man-made radionuclides in the surface layer of the soil (terrain).

The general radiological situation was measured before the start of the construction of NF from the year 1979 in the frame of the selection of the site - [I.8]. The level of external radiation measured with the pressure ionisation chamber type RSS-111 showed explicit space variations depending mainly on the character of the geological subsoil. The average value of such measured dose-rate is 95 ± 6,1 nGy/hour.

According the measurements provided by LRKO in 1992 (4.9.1992) [I.11] the average value of the external radiation measured with ionisation chamber RSS 111 on 15 places in the EMO environment was 94 ± 7,4 nGy/hour, what affirms the good repeatability of this quantity even in the period of 10 years – for details see chapter 4.8 of this POSAR [I.29].

The general radiological background on the site (i.e. also the values of external radiation) was influenced by the Chernobyl event, which changed the concentration of the fission products from atmospheric fallout significantly. The atmospheric fallout of the radionuclides was place-dependent different in dependence of local precipitation during the transfer of Chernobyl "cloud" – end of April and beginning of May 1986.

The values of external radiation measured by LRKO with help of ionisation chamber for the whole period of LRKO activity are presented on following pictures – Fig. 13-4 and Fig. 13-5. The values of the dose-rate in the localities Mochovce and Nový Tekov for the period 1987 to 2005 are displayed in the pictures. The ionisation chamber RSS 111 was replaced with the new ionisation chamber RSS 112 from the year 1996, what reflected with the slight values increase [I.13]. It is significant from the pictures that even after the start-up of NF (EMO12 in 1998 and RÚ RAO in 1999) the level of external radiation did not increase and, the values of the Mochovce site are comparable with values in Nový Tekov where the critical group of population from EMO12 operation till to now and MO34 future operation is situated regarding the dominant wind direction.

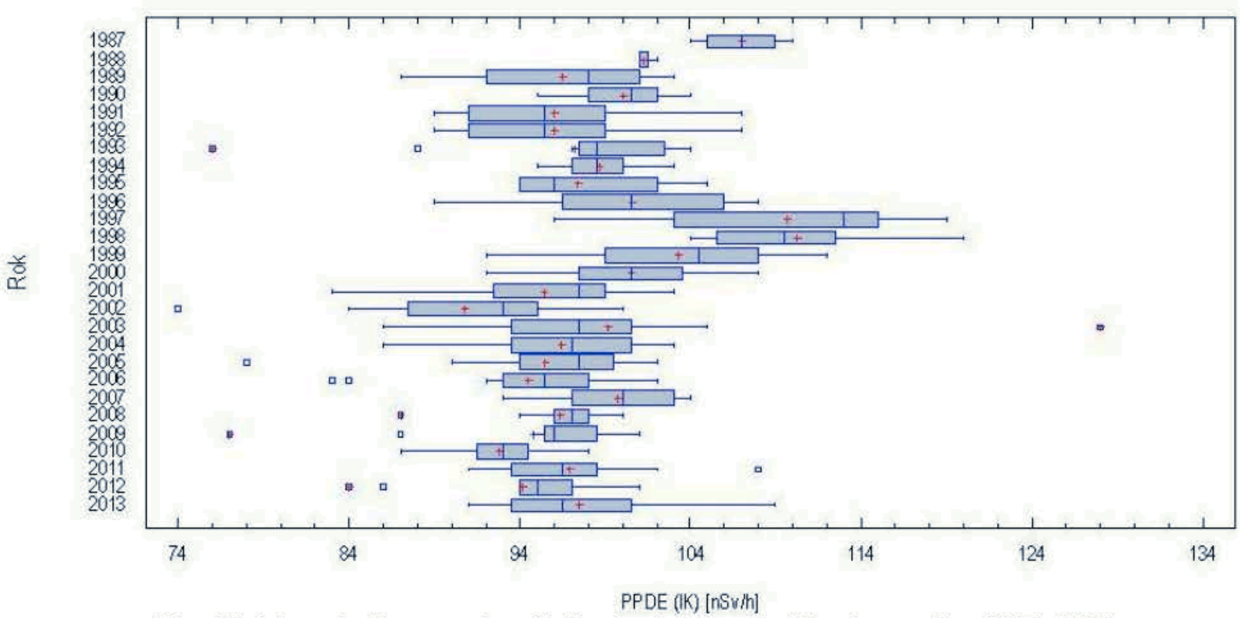

Fig. 13-4 Level of external radiation in the locality Mochovce for 1987- 2013

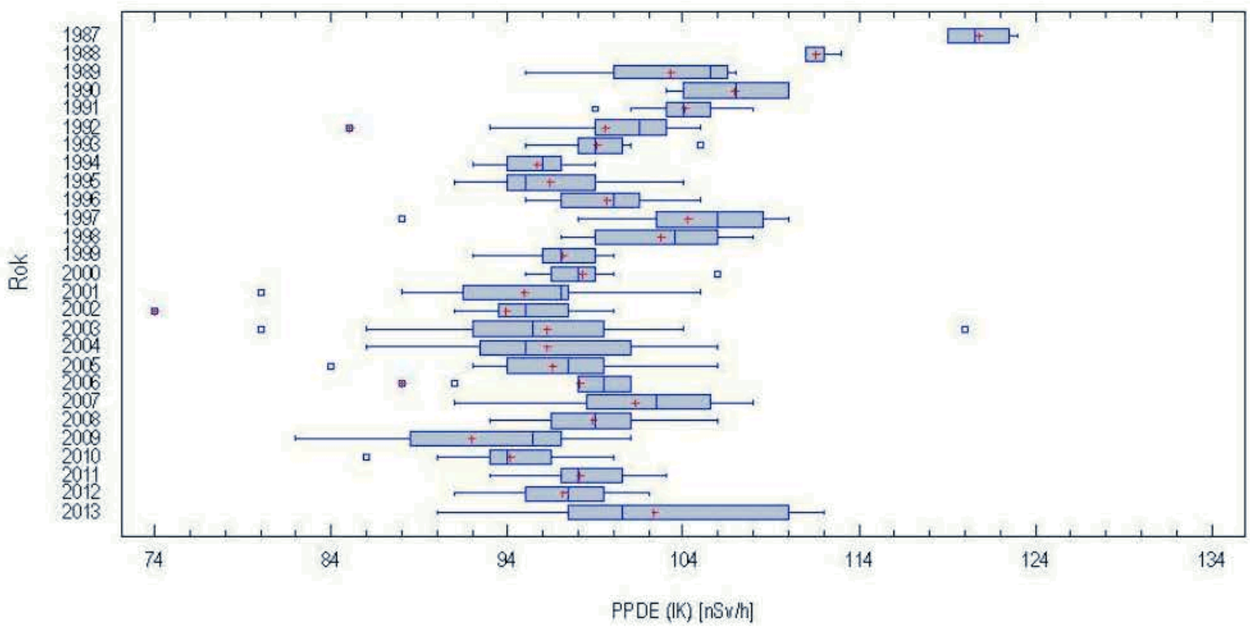

Fig. 13-5 Level of external radiation in the locality Nový Tekov in 1987 – 2013

13.1.3.3.2 *Activity of the radionuclides in the individual components of the living environment*

The activity of the radionuclides, especially of the man-made ones is generally very low in the samples of living environment. The evaluation of such low activities needs very sensitive methods of measurement and sufficiently large sample volumes. The survey realized in 1979-1982 [I.8] was based on measurement of so called gross beta activities ($\Sigma\beta$) related to the flat reference source $^{90}Sr+^{90}Y$ in the radioactive equilibrium. The contemporary procedures mainly thanks large-volume sampling equipment (air flow rate ≈ 200 m^3/hour) allow to measure reliable the activities of ^{137}Cs on the level of units of $\mu Bq/m^3$ after the sampling with duration of one week [I.20]. For the reason of operational monitoring, such sensitivity is not needed – e.g. in the stable radiological monitoring stations (SDS) in the environment of EMO the sampling devices with capacity of 60 to

80 m^3/hour of pumped air are used [I.15]. With such sampling equipment and with use of sufficiently long measuring time, it is possible to detect the activities on the level of units of µBq/m^3 - 1 week continual suction. Activity of ^{137}Cs in the airborne particulates derived from the global fallout is on the level of tenths of µBq/m^3 in the air of the ground layer of the atmosphere. In case of need e.g. long trend measurement of ^{137}Cs in the atmosphere it could be possible to use measurement of cumulative samples to increase the sensitivity of the measurement (month, quartal measurement at selected points).

For this reason the gross beta (Σβ) of the particulates in air is reused at the present. With this measurement it is possible operatively indicate noticeable weekly increase of volumic activity. Increased reference value of Σβ of aerosol then determines the order and the priority of the gamaspectrometry analysis of the individual aerosol samples in which the detection time is significantly longer (about 12 hours).

^{3}H in the surface waters - influence of NPP operation. The specific position in the monitoring of the radioactivity in the living environment has Tritium (^{3}H). It is a radionuclide, which is a part of the global fallout and passes into living environment via gaseous and liquid effluents. In so-called over-balance waters released into surface wastewater recipient, Tritium creates the dominant composition of the water activity. (This fact is characteristic one for the normal operation of NPP EMO12).

The radiological situation on the Mochovce site before the start-up of all NF on the site is described in details in the Chapter 04.08 of this POSAR [I.29]. It is possible to express that the contemporary radioactivity of the components of living environment on the Mochovce site (even after the start-up of operation of NF) is still of very low level. In the case of ^{137}Cs this fact is in accordance with general trend of radioactivity decrease in the living environment in the global scale. Best part of the radioactivity detected in the individual components of the living environment is created by the radioactivity of natural isotope of Potassium ^{40}K. An exception is atmosphere (airborne particulates and atmospheric fallout) where the cosmogenic radionuclide of Beryllium ^{7}Be prevails beside the general lower activity.

The results of LRKO monitoring and investigative levels of radioactivity in the living environment. In the individual components of the living environment and in the frame of the monitoring program of NPP EMO environment, the detailed statistical analyses from the results of few years are provided from time to time. The investigation reference levels are established on the basis of these analyses. In the case of the over-range of such levels, the reasons of the over-range are to be “investigated” and, on the basis of the investigation results, the measures are adopted. The over-range of the investigation level on the level of 3σ occurs very seldom – e.g. in the particulates activity caused by enhanced dustiness.

The activity of the long-living man-made radionuclides in the individual components of the environment is of very low level. The activities of ^{137}Cs and ^{90}Sr are measurable very seldom, mainly in particulates; fallouts; upper layer of the soil or in sediments. The activities of remaining man-made radionuclides are usually below the Minimum Detectable Activity (MDA) even if the methods and procedures for measurement with very high sensitivity are used. On the basis of the experience from radiological situation monitoring of natural samples, it is possible to express that the decrease of the activity of man-made radionuclides (mainly in the airborne particulates and fallouts) is observed during few last years, despite the short-term increase after the Chernobyl accident. The changes of remaining radionuclides (except in water) are not significant. In soil, which reflected accumulation of these radionuclides and components which manifest RN transport from soil is shown (components of food chain), the values of cumulated activity of these RN reduce but less significantly.

The volumic activity of Tritium in the Hron’s surface waters is usually low. Mostly, background levels are measured within the range of few Bq/l which has cosmogenic origin and to the surface waters they go via rainfalls. In places just below the entry site into the waste channel Hron (where the waste water released from

EMO12 are not fully mixed), especially in samples taken at the time of discharge of tritiated water can also be expected elevation of these background values, which is proportional to the dilution factor for effluents river Hron. The background level is represented by the value in Tlmace and Velke Kozmalovce - dam i.e. (0,6 - 5,5 Bq/l and 1,9 Bq/l in average), which has cosmogenic origin and to the surface waters they go via rainfalls. In the place of upstream the estuary of wastewater pipeline to the Hron and mainly in samples taken in time of tritium waters release is possible to expect these increased values. Volume activity of ^{3}H in the Hron wastewater discharge outlet was increased above the background level only in 2004 - Fig. 13-8. Presented values are from the Report on radioactivity monitoring in the environment of EMO in 2005 [I.13].

Influence of Chernobyl and Fukushima accident on background and investigation level. The Chernobyl accident in April 1986 demonstrates by increasing of the activity of man-made radionuclides in effect in all components of the living environment – see description of the model and its validation by measured after-Chernobyl data in [III.5], or report [III.7]. At the present, the influence of this accident is measurable only as ^{137}Cs in the soil (mainly on uncultivated land) from the places where more intensive precipitations occurred in the time of the radioactive cloud pass. Valid for remark is the transfer of the contamination ^{137}Cs in soils from the sharp slopes and in the consequence of water erosion; the accumulation of the contaminant in valleys or in the sediments in the surface streams passing through these valleys [III.4]. During the crossing of Chernobyl's cloud in May 1986, in EMO area were intensive rainfalls. As a consequence there is increased deposit of ^{137}Cs in soils.

In the soils the mass activity of artificial RN in surface layer after Chernobyl accident was reduced by tillage. Moreover there is permanent erosion by wind and water, mainly on hillsides with combination with tillage, contributes to reduction of RN concentrations in the surface layer. Contrariwise, at the places of cumulating of soils layer washed away the surface activity of these RN is increasing. These two precesses contrarz to each other create natural conditions for more evident differences (heterogeneity of contamination) in concentrations of artificial RN in surface layer. This makes the interpretation of measured values more complicated. Substantially were contaminated other places of Mochovce area, which is proved by monitoring results performed by LRKO in surroundings EMO12, listed in Tab. 13-16.

Increased levels of ^{137}Cs in soils in most contaminated places slightly increase background level of external irradiation from natural RN like ^{40}K, , U- a Th- series in surroundings - for more details see chapter 4.8 of this POSAR [I.29].

This parameter is more important for the proof that the influence of EMO on environment is not significant. Reference level for judgment of increase of ^{137}Cs concentration in environment as a consequence of NPP operation is this (for this fission RN) slightly increased level. During the measurement of its increase it is necessary to take into account not only device background (e.g. in case of ^{60}Co), but also increased level of its occurrence in the environment (soil, food chain|. This can make more difficult for demonstrating the negligible impact of NPP operation on the environment.

On other side, these background (fission) RN can be indicator of abnormal state of NPP operation (increased activity of these RN in releases), mainly if there is operation with damaged fuel cladding (this case did not occurred at EMO12 NPP). Contrary in these cases the most significant indicator RN would be ^{137}Cs and radiologically the most significant would be ^{90}Sr, ^{239}Pu a ^{241}Am, too.

Tab. 13-15 Results of the field gamma spectroscopy measurements in Vrable (1992 and 2010)

Radionuclide	Activity		Dose rate, [nGy/h]	
	1992	2010	1992	2010
Man-made	[Bq/m^2]			
^{134}Cs	620 ± 90	< 273	2,2 ± 0,3	< 0,3
^{137}Cs	8660 ± 170	4290 ± 470	11,5 ± 0,2	5,18 ± 0,57
Natural	[Bq/kg]			
^{40}K	530 ± 10	615 ± 58	22,8 ± 0,6	25,6 ± 2,4
U-series	33 ± 8 (1)	35,5 ± 6,0 (1)	14,4 ± 3,4 (2)	17,5 ± 1,8 (2)
Th-series	34 ± 7 (1)	39,3 ± 10,2 (1)	22,1 ± 4,7 (2)	24,0 ± 2,0 (2)
Total			73,0 ± 5,0	72,3 ± 1,8
Measured by the ionisation chamber including the cosmic radiation			101,0 ± 4,0	90 ± 4

(1) – Activity of one element of the decay series

(2) – Dose rate from all elements of the decay series in equilibrium

In- situ semiconductor gamma-spectrometry is effective, which is able to measure the activities of RN emitting gamma radiation from larger area without sampling, to average activity on this area and mainly to distinguish in the dose rate of gamma radiation the artificial RN from natural ones. For example, with help of field spectroscopy "in situ" the activities of ^{137}Cs and ^{134}Cs were measured in the locality Vrable in 1992. These activities influenced significantly the level of dose-rate of external radiation from terrestrial component (in the comparison with pre-Chernobyl situation). The result of the field "in situ" spectroscopy in this locality in 1992 and 2010 are listed in Tab. 13-15. The comparison of this both values sets will show that the slight decrease of value of external radiation was caused by decrease of the activity of man-made radionuclides ^{137}Cs and ^{134}Cs. The question is if the measurements in 2010 trustily represent the position and conditions in 1992.It would be possible to declare by series of measurement next to each other, which would exclude the influence of human factor in the measurement point (interference with the surface layer of the ground, etc.).

NPP Fukushima accident was noticed in March 2011 by increased levels of volumic activity of the most important short living fission RN ^{131}I in the aerosols in the atmosphere in SR (the maximum around 1 mBq/m^3, (www.uvz.sk)). For ta few month there was increased ^{137}Cs as well (tens of μBq/m^3). These activities in atmosphere have no impact on levels of deposit in SR.

Summary. On the basis of above mentioned it is possible to express, that the evaluated values of typically background levels of radioactivity in the atmosphere and fallouts are situated in the standard intervals corresponding to the contemporary global contamination of the biosphere. These values in the case of ^{137}Cs are order below the limits of analytical possibilities (MDA) of present used routine monitoring methods in LRKO Levice.

Contrary, still increased levels of uneven distribution of ^{137}Cs surface activity (in comparison with Bohunice locality). The highest concentrations of ^{137}Cs in soils are at places of increased contamination by Chernobyl fallout (Tab. 13-16), which were not influenced by agricultural activities from 1996 (forest land, permanent grassland). In forest land, the highest activities of ^{137}Cs (e.g. around 500 $Bq.kg^{-1}$ in close surrounding of RÚ RAO) were found in surface layer of humus.

In Fig. 13-7 is as an example the model of spatial distribution of ^{137}Cs activity in surrounding of RÚ RAO [III.5], [III.6]. RÚ RAO is as rectangular yellow area (low activities). Map of isolines shows the segmentation of the terrain (altitude). Map shows the places with substantial cumulating of Cs – valley of basin (soils along the creeck, but also in the valley of hillsides).

Chernobyl deposit is evident from radioactivity of ^{137}Cs in soils, which is increased in some points. It is seen from Tab. 13-16 (the highest values are bolded) or from Fig. 13-7, where spatial distribution of ^{137}Cs in first 5cm layer of soils is displayed. From Tab. 13-16 it is evident that in 3 places is soils activity above 150 Bq/kg.

The level of ^{137}Cs in waters is also very low – on the level of 1 mBq/l. The selective measurements of such low activities are possible only by use of specific concentrations methods which need according experience to apply appropriate attention to quality control and to the metrology verification of the procedures and instruments used for these measurements.

It is possible to illustrate **the character of the changes of radioactivity in the components of living environment on the Mochovce** site on the results of long-term monitoring of the selected components of living environment. Most representatives, from the point of long-term view, are the results of dose rate monitoring (Fig. 13-4 and Fig. 13-5) and the results of measurement of ^{137}Cs radionuclide in the soil. These results demonstrate clearly the influence of external sources on the background values on the site and demonstrate the long-term decreasing trend. In the case of soils it is shown effect of already mentioned gradually thinning of ^{137}Cs activity in the surface layer of soils (tillage) and increase of surface activity below the hillsides and along the basin (water erosion consequence): washed out soil particles are cumulating (except of cumulating zones) in water reservoir closing the basin. Balance of bed sediments is more detailed described in chapter 04.08 of this POSAR [I.29] for Čifáre pond. It is necessary to calculate with heterogeneous distribution of original deposit in specific places in change of soil sampling point [III.4].

Tab. 13-16 Mass activity of ^{137}Cs in Bq.kg^{-1} in first 0-5cm layer of soil sampled within survey in 1989 mostly from not tillaged soil taken from the study "Baseline.." for MŽP SR

No.	Locality	^{134}Cs	^{137}Cs	No.	Locality	^{134}Cs	^{137}Cs
1	Malé Kozmálovce	1,69	71,4	30	Hronské Koslhy	3,01	**122,9**
2	Nový Tekov	0,75	30,5	31	Čajkov-vinice	2,32	96,6
3	Nemčlňany	1,01	36,2	32	Nová Dedina-vinice	3,81	**159,2**
4	Červený Hrádok	1,74	73,8	33	Nová Dedina	0,56	23,2
5	Cifáre	1,34	50,7	34	Nemčiňany – Dobrica	0,63	30,7
6	Velký Dúr	2,02	81,2	35	Korlát-Majer	3,76	**190,0**
7	Kalná n/Hronom	0,47	18,4	36	Kozárovce	0,60	30,1
8	Tajná	0,74	30,5	37	Kováčov pot,-Tehla	0,38	19,8
9	Levice	1,18	51,1	38	Liska-Iňa	1,24	61,1
10	Kozárovce	2,21	90,0	39	Tehla-ornica	0,61	27,0
11	Rybník	3,02	**121,8**	40	Slepčany	-	14,8
12	Kalná n/Hronom	0,69	27,1	41	Sándorhalma	0,35	18,6
13	Velký Dúr	1,76	69,6	42	Nemčiňany-ornica	0,71	36,9
14	Červený Hrádok	1,92	75,4	43	Horná Seč	-	11,4
15	Cifáre	1,05	44,2	44	Vyšné n/Hronom	0,49	24,8
16	Lok	-	15,3	45	Starý Hrádok	0,78	38,8
17	Velké Kozmálovce	4,07	**158,2**	46	Margita-Ilona	-	13,4
18	Nevidzany-Ohaj	1,89	75,2	47	Dolné Lúky	0,45	22,8
19	EMO	3,45	**137,4**	48	Volkovce	0,48	22,3
20	Nemčlňany	0,87	34,8	49	Psiare	-	13,4
21	Malé Kozmálovce	2,01	81,3	50	T,Mlyňany-St, Háj	0,83	41,5
22	Nový Tekov	1,40	56,9	51	Melek	0,97	50,2
23	Hronské Kľačany	1,56	67,0	52	Mochovce-potok	-	4,1
24	Tajná	1,98	75,2	53	Géňa	-	8,4
25	Kalná n/Hronom	0,79	30,8	54	Čajkov	1,73	85,0
26	Ladislavov dvor	-	11,8	55	Gondovo	1,09	55,2
27	Strážny vrch-Levice	2,19	88,6	56	Nová Dedina	1,56	78,3
28	Marušová - Podlužany	1,15	49,8	57	Kmeťovce	1,24	62,2
29	Starý Tekov	0,34	12,8	58	Krškany	0,55	27,5

Activities of ^{137}Cs in individual layers for years 2006 - 2010 are presented in the following table Tab. 13-17.

Tab. 13-17 Mass Activity of ^{137}Cs in soils, in city Vráble

Year	Mass activity of ^{137}Cs in soil		
	0-2 cm	2-5 cm	5-10 cm
2006	43,2	47,0	28,3
2007	50,5	60,2	35,3
2006	61,5	59,3	52,2
2009	53,4	64,7	48,7
2010	39,3	55,0	38,7
2011	19,9	37,8	36,8
2012	33,3	43,3	33,5
2013	34,4	42,4	29,6

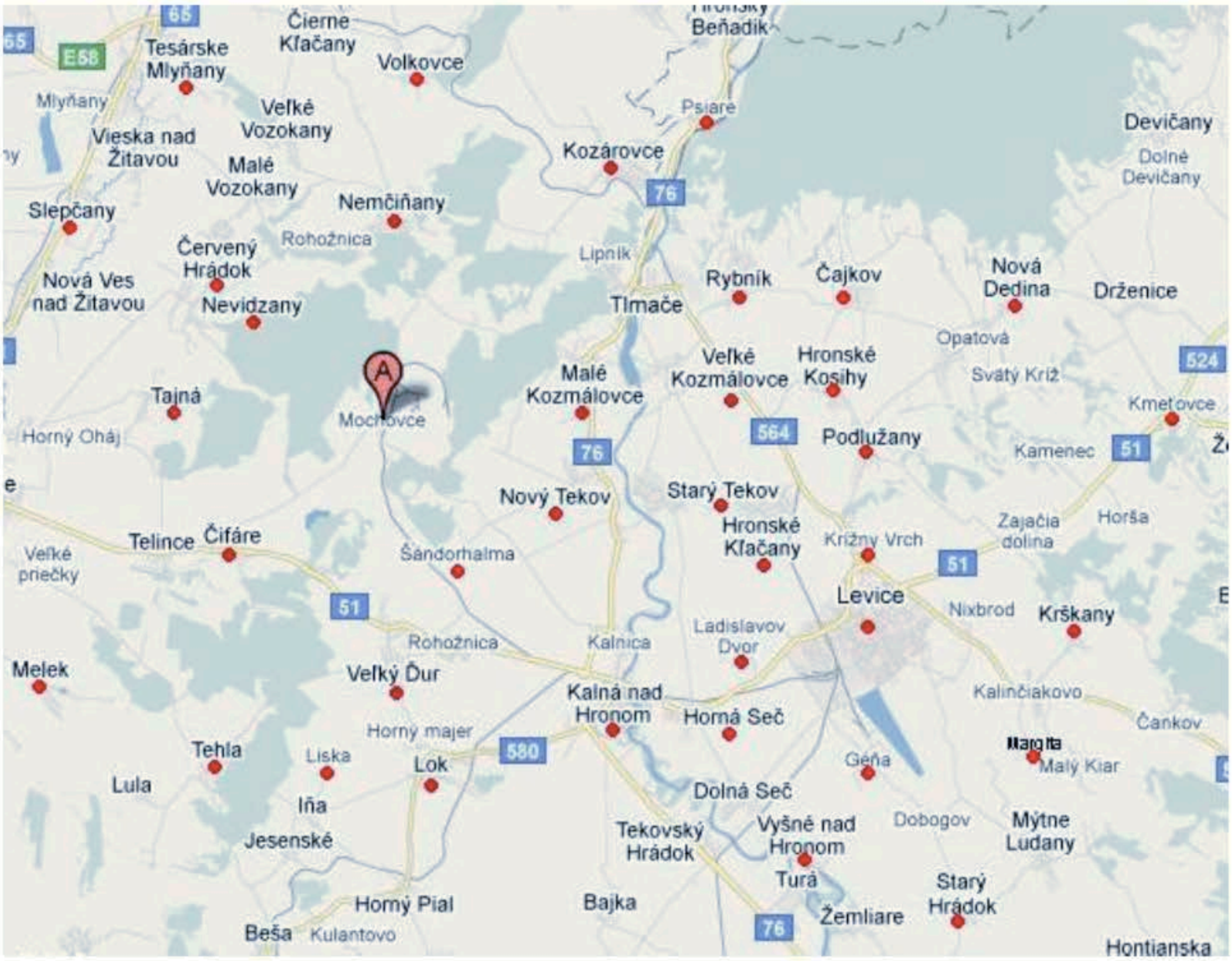

Fig. 13-6 Sampling points for determinatin of mass activity in soils presented in Tab. 13-16

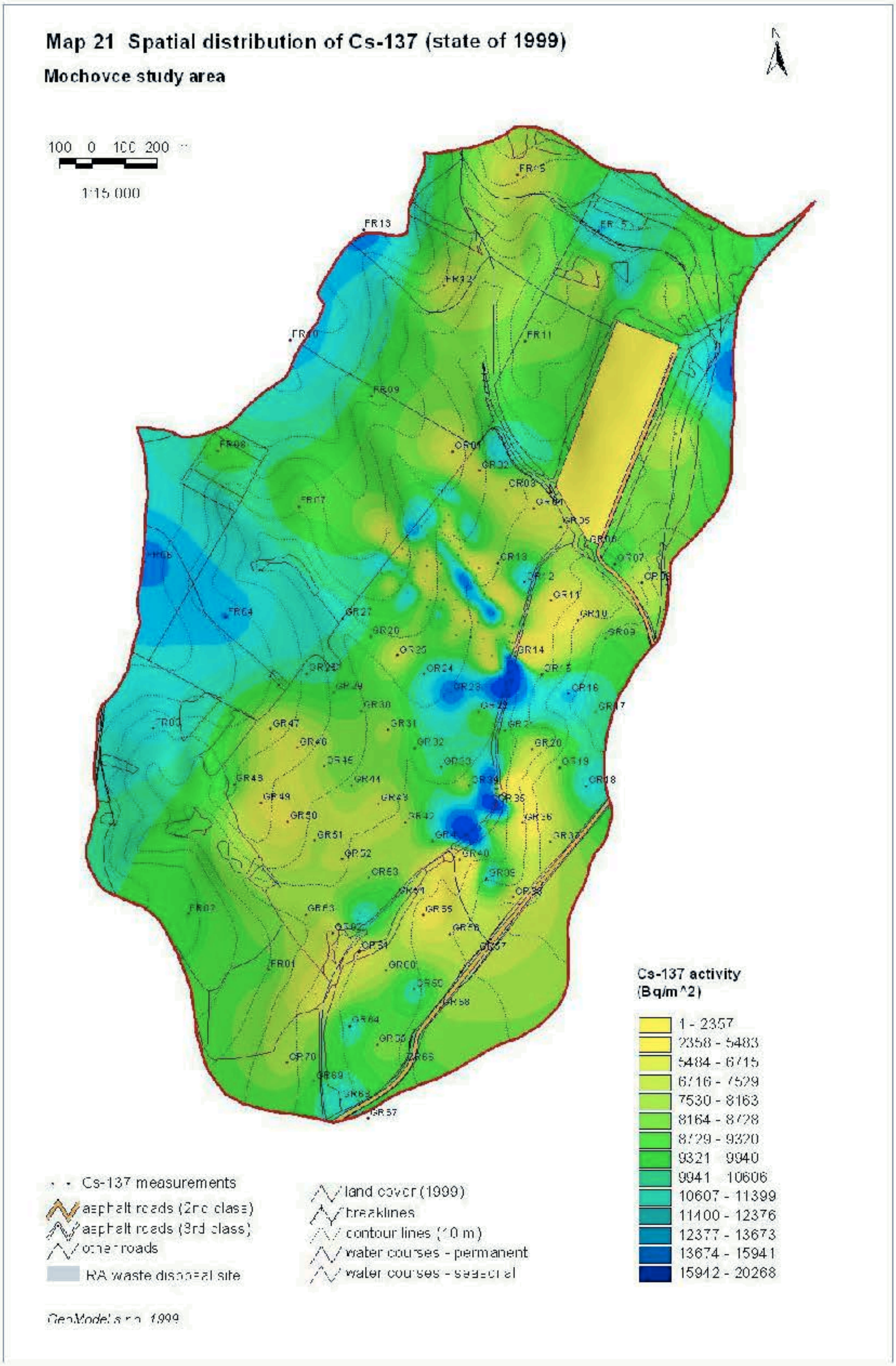

Fig. 13-7 Spatial Distribution of 137Cs in the surroundigs of RÚ RAO Mochovce (project SPARTACUS)

The volume activity of Tritium ^{3}H in the Hron River downstream the estuary of the wastewater was increased above the background level (units of Bq/l) only in 2004. Fig. 13-8. The origin of increased values is date of sampling – tritium waters were released to the Hron river.The background level is represented by the value in Tlmace and Velke Kozmalovce - dam i.e. upstream the estuary of wastewater pipeline, it means values in range of 0,6-5,5 Bq/l (average 1,9 Bq/l).

Presented values are from the Report on radioactivity monitoring in the environment of EMO in 2010 [I.13].

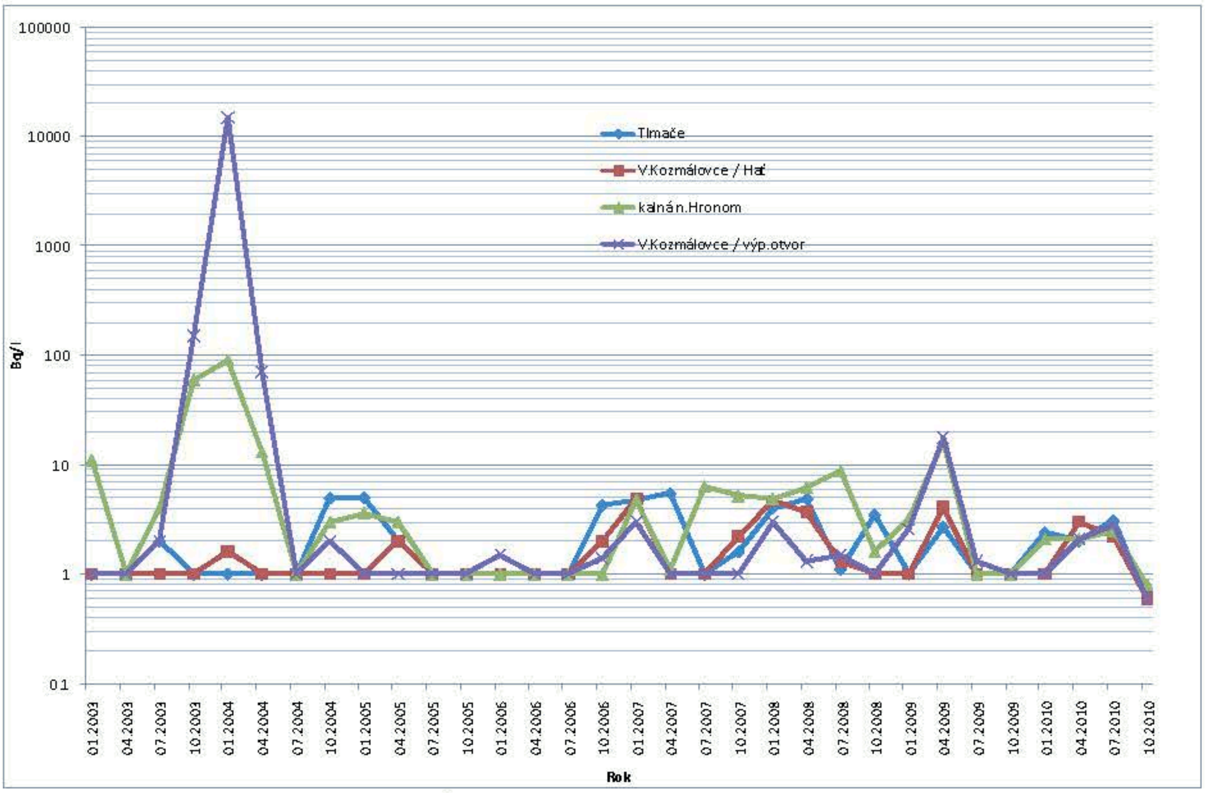

Fig. 13-8 Time course of Tritium ^{3}H volume activity in surface waters – the Hron River

13.1.4 Evaluation of the impact of operation of EMO12 till to now to the living environment

13.1.4.1 *Releases of radioactive substances from EMO12 operation and their comparison with limits*

The operation of EMO34 will be controlled in such a way as to not exceed the annual reference levels of releases into atmosphere and hydrosphere established by Chief Hygienist of the SR in his Decision No OOZPŽ/6773/2011 [I.3] on introduction of radioactive substances into the environment by releases through the ventilation stack and by waste water releases through pipe from the EMO site into river Hron - see chapter 13.1.1. This conclusion can be supported by up to date knowledge of radioactive substances releases into the environment of the EMO - see Tab. 13-6 and Tab. 13-7.

The comparison of these limits for NF in the Mochovce site with limits of releases from NF on the Bohunice site is in Annex 1. In Annex 2 there are assigned the values of real releases from individual NF on the site Bohunice and on the site Mochovce (averages for years 1999 to 2002) as well as the percentage expression of the real release to the limit. It is possible to observe that except liquid releases into the Hron River and the Váh River does not exceed 1% of the limit.

Note: The radioactivity of the Tritium contaminated waters released to the surface waters (the Hron River) trough so called "tritiated waters" is dependent on the concentration of ^{10}B in the coolant. The new generation of nuclear fuel with admixture of Gadolinium (Gd_2O_3), used from the last year allows lowering the concentration of ^{10}B in the coolant. This fact will bring decrease of the radioactivity of ^{3}H released to living environment [I.21].

RN composition of releases from NPP - balance of RN in yearly releases will influence RN concentration levels in elements of environment in the surrounding of NPP. Therefore it is necessary to compare RN composition in environmental samples (relative ratio of radionuclides) with RN composition in releases for given time period and to judge if measured RN in environmental sample can come from operation of NPP or it is consequence of external radiation source.

13.1.4.2 Balance of releases of RN into the atmosphere

Long time composition of RN in atmospheric releases of aerosols according to [I.33] is given in Tab. 13-18 (years 1999 – 2007). Composition of RN in atmospheric effluents according to [I.13] is presented in Tab. 13-19. From Tab. 13-18 and Tab. 13-19 is visible that dominant longterm RN in releases of aerosols were: ^{110m}Ag, ^{58}Co, ^{60}Co a ^{54}Mn. Similar RN composition is expected to be in samples of air aerosols and fallouts in EMO surrounding, if their radioactivity would be releases from stack of NPP EMO12.

Influence of RN half time in releases is given in last column of Tab. 13-18, where are values of cumulative release for years 1998-2007, taking into account radioactive decay. The most dominant RN in cumulative release is long-time ^{60}Co (T1/2 about 5.3 year) followed by shorter-time ^{110m}Ag (T1/2 = 250 days). Cumulative release of RN is equal to sum through individual years corrected on decay according to the following formula:

$$K_i = \sum_j A(t_j)\exp\left(-\lambda\left(t_{akt} - t_j\right)\right)$$

These RN, if their released activities would be enough high, it would be expressed by increased activities of deposit and finally in **soils and in food chain**, which is closely connected with soils. At the same time, this could cause increased value of external gamma dose rate. **It is necessary to emphasize that nothing similar occurred in 1998 and later.**

Interesting is presence of ^{54}Mn (312 days) at start of operation (first two years 1999 and 2000). Its average yield in years 1998 - 2007 is 18%. Later from 2003 is visible activity increasing of ^{110m}Ag (250 days), which exceeded activity of ^{54}Mn and becomes dominant RN in atmospheric releases (aerosols). Its average yield in years 1998 - 2007 is 33.5 %. Next activation product ^{60}Co (5 years) is at stable level (1-2 MBq/year) in releases, it means average years yield around 11%. As was already mentioned it is most dominant RN from point of view of activity cumulation in soil, because its activity in soil is increasing with time.

RN composition of releases and presence of fision products in coolant of primary circuit. From Tab. 13-18 and Tab. 13-19 is visible that activity of ling time living ^{137}Cs (halftime 30 years) is one order lower in comparison with ^{60}Co in the releases. Presence of well-known RN (global and Chernobyl deposit) in environment elements in the surroundings of reference EMO12 doesn't relate with impact of the NPP on environment, because concentrations of ^{60}Co in soils would be significantly higher in comparison with ^{137}Cs, with similar relative ratio as in releases in Tab. 13-18. Concerning RN in releases it is necessary to highlight that many values in Tab. 13-18 are on basis of MDA (in reality they weren't measurable in releases, their activities were below MDA – see Tab. 13-20). Therefore the percentage data in table are conservative and in some cases only informative). This is also case of ^{137}Cs, which balance for year 2006 after neglecting of MDA values would be according to Tab. 13-20 at level of 88% of presented released year value. It means that its percentage yield during last watched 10 years could be lower in comparison with value in table.

Measurements of atmospheric releases clearly demonstrate that status of fuel cladding is excellent without clear damage in EMO12 NPP. Fission products (^{137}Cs representative) are fixed under fuel cladding, it means that there is not releasing into water of primary circuit, neither to the environment.

Tab. 13-18 Overview of RN yield in annual EMI12 air pollutants into the atmosphere (aerosols), 1998 - 2002.

AEROSOLS [MBq]	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average 99-07	%	Cumul. releases.
Sc-46	-	0,00	-	0,02	0,02	0,02	0,02	0,05	0,07	0,03	0,03	0,23	0,01
Cr-51	0,15	0,39	0,21	1,59	0,65	1,50	0,39	1,08	1,75	1,62	1,02	8,79	0,02
Mn-54	0,02	1,03	2,14	5,82	1,96	2,79	1,12	1,47	1,58	0,88	2,09	18,0	1,44
Fe-59	0,03	0,29	0,09	0,77	0,42	0,28	0,11	0,25	0,34	0,20	0,31	2,65	0,01
Co-57	0,01	0,01	0,02	0,02	0,01	0,02	0,01	0,03	0,03	0,02	*0,02*	0,17	0,02
Co-58	0,02	0,78	0,31	2,32	1,38	3,02	0,79	1,21	2,02	0,95	1,42	12,3	0,17
Co-60	0,01	0,21	0,72	2,16	1,04	1,47	0,82	1,53	1,98	1,41	1,26	10,9	7,13
Zn-65	0,03	0,02	0,05	0,11	0,10	0,06	0,04	0,10	0,15	0,07	*0,08*	0,67	0,08
Se-75	-	0,01	-	0,03	0,02	0,02	0,03	0,07	0,12	0,04	0,04	0,37	0,02
Zr-95	0,02	0,11	0,06	0,83	0,25	0,22	0,09	0,25	0,47	0,27	0,28	2,44	0,04
Nb-95	0,02	0,19	0,10	1,72	0,57	0,24	0,05	0,24	0,38	0,27	0,42	3,61	0,01
Ru-103	0,01	0,01	0,02	0,14	0,12	0,06	0,03	0,06	0,10	0,04	0,06	0,56	0,00
Rh-106	0,03	0,03	0,06	0,06	0,04	0,05	0,06	0,13	0,18	0,08	0,08	0,66	0,00
Ag-110m	0,01	0,01	0,48	1,29	0,43	2,36	4,18	13,25	9,28	3,73	3,89	33,5	5,48
Sb-122	-	0,04	-	-	0,07	0,07	0,08	0,18	0,25	0,18	0,13	1,08	0,00
Sb-124	0,01	0,03	0,03	0,23	0,11	0,16	0,09	0,21	0,43	0,26	0,17	1,48	0,03
Cs-134	0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,04	0,06	0,02	0,03	0,23	0,09
Cs-137	0,02	0,01	0,03	0,04	0,04	0,03	0,04	0,12	0,13	0,07	0,06	0,49	0,47
Ce-141	0,03	0,02	0,04	0,06	0,04	0,03	0,03	0,05	0,07	0,03	0,04	0,35	0,00
Ce-144	0,10	0,07	0,15	0,10	0,10	0,08	0,10	0,24	0,26	0,12	0,14	1,18	0,18
Hf-181	-	-	-	0,03	0,03	0,02	0,03	0,05	0,08	0,06	0,04	0,37	0,00
Sum	0,54	3,4	4,5	17,4	7,4	12,5	8,1	20,6	19,74	10,3	11,6	100	15,2

Note:
Some values are given as Minimum detectable activities (were not measured in releases –see Tab. 13-20), thereforethe percentual composition data are conzervative and in somecase only informative.

Tab. 13-19 Composition of RN in EMO12 atmospheric effluents in years 2008 - 2014

Rádionuclide	Unit	2008	2009	2010	2011	2012	2013	2014	Average 2008-2014	%
H-3	GBq	584.2	510.1	220.6	508.2	689.4		685.5	533.0	21.38
CO2-anorg.	GBq	18.93	16.73	17.37	26.25	29.93		31.23	23.41	0.94
CnHm-org.	GBq	328.80	292.00	295.40	442.70	469.30		452.60	380.13	15.25
Ar-41	GBq	868.00	782.70	995.90	1258.00	1097.00		862.10	977.28	39.20
Kr-85	GBq	387.30	392.50	26.24	435.70	439.50		324.50	334.29	13.41
Kr-85m	GBq	9.06	11.95	14.76	15.54	8.10		5.70	10.85	0.44
Kr-87	GBq	28.75	28.04	33.75	39.57	31.15		23.88	30.86	1.24

Rádionuclide	Unit	2008	2009	2010	2011	2012	2013	2014	Average 2008-2014	%
Kr-88	GBq	27.92	26.85	32.12	36.16	27.71		21.82	28.76	1.15
Xe-131m	GBq	78.18	81.03	81.29	26.00	25.30			58.36	2.34
Xe-133	GBq	25.66	30.26	38.70	16.50	15.51		16.77	23.90	0.96
Xe-133m	GBq	15.50	15.92	16.49	118.40	48.30		11.31	37.65	1.51
Xe-135	GBq	76.66	96.74	141.80	0.04	0.05		10.90	54.37	2.18
I-131 aer.	MBq	0.04	0.04	0.03	0.47	0.23		0.03	0.14	0.00
I-132 gas	MBq					51.03		0.42	25.73	0.00
I-131 gas	MBq	0.15	0.21	0.21	0.90	0.98		51.16	8.93	0.00
I-133	MBq	1.10	1.04	0.94	1.04	1.35		1.49	1.16	0.00
Sc-46	MBq	0.03	0.03		0.75	1.83			0.66	0.00
Cr-51	MBq	0.74	1.04	1.28	0.14	0.21		1.73	0.85	0.00
Mn-54	MBq	0.67	1.10	1.24	0.01	0.02		1.41	0.74	0.00
Fe-59	MBq	0.13	0.23	0.25	1.01	1.03		0.27	0.49	0.00
Co-57	MBq	0.02	0.02	0.02	1.44	3.23		0.02	0.79	0.00
Co-58	MBq	0.82	1.53	2.27	0.06	0.08		1.55	1.05	0.00
Co-60	MBq	1.28	1.84	1.85	0.05	0.04		1.28	1.06	0.00
Zn-65	MBq	0.06	0.07	0.08	0.36	0.26		0.08	0.15	0.00
Se-75	MBq	0.03	0.03	0.70	6.57	35.87		0.84	7.34	0.00
Zr-95	MBq	0.18	0.23	0.81	0.25	0.41		0.43	0.39	0.00
Nb-95	MBq	0.17	0.15	0.39	0.19	0.32		0.98	0.37	0.00
Ru-103	MBq	0.03	0.03	0.04	0.03	0.04		0.04	0.04	0.00
Rh-106	MBq	0.07	0.08	0.07	0.07	0.10		0.07	0.08	0.00
Ag-110m	MBq	3.56	6.41	2.93	4.55	10.99		2.06	5.08	0.00
Sb-122	MBq	0.13	0.16	0.23	0.20	0.06		0.07	0.14	0.00
Sb-124	MBq	0.18	0.34	0.32	0.20	0.29		0.23	0.26	0.00
Cs-134	MBq	0.02	0.03	0.02	0.03	0.03		0.02	0.03	0.00
Cs-137	MBq	0.05	0.06	0.05	0.06	0.08		0.04	0.06	0.00
Ce-141	MBq	0.03	0.03	0.03	0.03	0.04		0.04	0.03	0.00
Ce-144	MBq	0.12	0.12	0.11	0.12	0.16		0.10	0.12	0.00
Hf-181	MBq	0.07	0.08	0.11	0.08	0.11		0.16	0.10	0.00
Sr-89	kBq	0.95	0.60	0.97	1.10	1.10		1.03	0.96	0.00
Sr-90	kBq	6.20	2.31	3.98	3.92	1.19		4.70	3.72	0.00
Pu-238	kBq	0.40	0.01	0.03	0.03	0.03		0.03	0.09	0.00
Pu-239+240	kBq	1.31	0.50	0.38	0.49	0.18		0.03	0.48	0.00
Am-241	kBq	0.07	0.71	0.12	0.12	0.03		0.03	0.18	0.00
SUM	**GBq**	**2449**	**2285**	**1914**	**2923**	**2881**		**2446**	**2493**	**100.00**

Note: *Some values are MDAs (in reality were not measured. - see Tab. 13-20), therefore information about parcentage composition are rather conservative and in some case only informative.*

Actual levels of gaseous exhalants in the stack are on very low hardly measured levels (even with use special highly sensitive and expensive devices), in case of operation with undamaged fuel (device of Berthold company for aerosols and iodine and Hartman & Braun for radioactive noble gases detector (monitor NGM-215 at MO34)). Continual measurement of aerosols and ^{131}I even with these devices is replaced by short-time periodic measurement. Continual measurement of actual volumic activities is possible to realize only for radioactive noble gases (device SB-150 with MDA cca 500 Bq/m^3), for volumic activities of noble gases and short-time living releases of aerosols and iodine indicating limits of normal operational status and especially case of normal operation and separately for releases during outage (opened reactor).

Tab. 13-20 Example of balance comparison of radionuclides in dependence of including MDA for gaseous releases in 2006

Parameter		Bilancia s MDA	Bilancia bez MDA	Podiel %	Bilancia len z MDA	Podiel %
Trícium H-3	GBq	2,905E+02	2,905E+02	100,0%	0,000E+00	0,0%
I-131 aer.	MBq	8,295E-02	2,397E-03	2,9%	8,055E-02	97,1%
I-131 ply.	MBq	3,470E-01	3,438E-01	99,1%	3,190E-03	0,9%
Cr-51	MBq	1,751E+00	1,496E+00	85,4%	2,552E-01	14,6%
Mn-54	MBq	1,578E+00	1,578E+00	100,0%	0,000E+00	0,0%
Fe-59	MBq	3,447E-01	2,852E-01	82,7%	5,952E-02	17,3%
Co-57	MBq	3,360E-02	2,121E-03	6,3%	3,148E-02	93,7%
Co-58	MBq	2,024E+00	2,021E+00	99,9%	2,116E-03	0,1%
Co-60	MBq	1,975E+00	1,975E+00	100,0%	0,000E+00	0,0%
Zn-65	MBq	1,549E-01	5,297E-02	34,2%	1,020E-01	65,8%
Zr-95	MBq	4,694E-01	4,196E-01	89,4%	4,982E-02	10,6%
Nb-95	MBq	3,830E-01	2,987E-01	78,0%	8,438E-02	22,0%
Ru-103	MBq	9,694E-02	4,903E-02	50,6%	4,791E-02	49,4%
Rh-106	MBq	1,832E-01	0,000E+00	0,0%	1,832E-01	100,0%
Ag-110m	MBq	9,279E+00	9,279E+00	100,0%	0,000E+00	0,0%
Sb-124	MBq	4,324E-01	4,069E-01	94,1%	2,543E-02	5,9%
Cs-134	MBq	5,855E-02	0,000E+00	0,0%	5,855E-02	100,0%
Cs-137	MBq	1,332E-01	1,669E-02	12,5%	1,165E-01	87,5%
Ce-141	MBq	7,189E-02	1,313E-03	1,8%	7,057E-02	98,2%
Ce-144	MBq	2,567E-01	5,260E-02	20,5%	2,041E-01	79,5%
Sr-89	kBq	1,527E+00	0,000E+00	0,0%	1,527E+00	100,0%
Sr-90	kBq	6,187E+00	6,187E+00	100,0%	0,000E+00	0,0%
Pu-238	kBq	3,521E-01	3,521E-01	100,0%	0,000E+00	0,0%
Pu-239+240	kBq	5,303E-01	5,303E-01	100,0%	0,000E+00	0,0%
Am-241	kBq	3,990E+00	3,990E+00	100,0%	0,000E+00	0,0%
Aerosóly - suma	MBq	1,923E+01	1,794E+01	93,3%	1,292E+00	6,7%
Suma I-131	MBq	4,299E-01	3,462E-01	80,5%	8,374E-02	19,5%
Rádioaktívne vzácne plyny	GBq	3,061E+03	2,444E+03	79,8%	6,171E+02	20,2%

Optimization of radioactive releases is ensured besides technological radiological controls (gas, wastewater polishing system,) also by not exceeding of mentioned ALARA reference levels (investigation or action can be done before exceeding of investigation level) as well. Maximum allowed values of total releases activities are derived from concentration limits or PHA annual reference levels of discahges. The base for regulation and not overrun of PHA annual reference levels of releases is the system of reference values at level 0,2 - record (deviation), 1,0 - investigation and 5,0 multiple (action) of daily value of PHA annual reference levels of discahges. Checking and compliance of reference levels finally leads to **ALARA optimization of radioactive releases from NPP**.

The price for this possibility earlier intervention is evidently increased expenses for procurance and operation of more sensitive measurement devices of releases in comparison with commonly used monitors (by about 1 order). The reason is, in comparison with western NPPs one order higher air flow in satck of NPP VVER and therefore one order higher reduction of activity concentration. The most sensitive tool for control of ALARA levels is high sensitive continual monitor of radioactive noble gases.

In case of fulfilment of other reference levels (investigation, action) it ensured also not exceeding of authorized values of releases for individual release pathways. From project point of view it means also ensure not exceeding of limit values of doses to population.

Exceeding of noble gases volume activities reference levels is online controlled by online system ISRK and by shift engineer of radiation control. Nowadays at EMO12, after end of day, the daily balance of releases of radioactive noble gases release is done by shift engineer, and it is checked if reference levels were or were not exceeded and preliminary percentage of yearly limit is checked. After exceeding of the levels the procedures are performed to the intent of valid documents of EMO (control, check, identification, inform, written messages…). Technician of radiation safety (responsible for balance of radioactive releases) performs monthly balance of radioactive releases in comparison with yearly limit, checks trends etc. This is valid in similar way for aerosols and ^{131}I as well.

According to report on PSR of reference EMO12 NPP, the composition of releases were not significantly changed during the operation as it follows from data in Tab. 13-18: the main RN indicator of EMO impact on surroundings could be presence of ^{110m}Ag and ^{54}Mn in samples characterizing present releases (aerosols, fallouts), possibly ^{60}Co and ^{110m}Ag in samples with cumulative deposit in NPP surrounding (soils and food chain).

The quality of fuel rods cladding in EMO12 remained on high level for all time of operation without evident damage with minimum presence of fission products (^{137}Cs, ^{134}Cs, and so on) in releases, cooling medium of I.O. and finally in NPP releases as it follows from Tab. 13-18.

Obviously, if during the MO34 operation would be a damaged (but allowed level) fuel, it will be necessary to take into account substantial yield of fission product in releases as well as in environmental samples - From long-time point of view the most important RN would be ^{137}Cs, ^{90}Sr, which could exceed ^{60}Co. From the short living RN are iodine isotopes, mainly ^{131}I with halftime of 8 days.

13.1.4.3 Balance of radioactive releases into hydrosphere

Recording of radioctive releases is based on records of all released control tanks. For each tank the total beta activity and activity of tritium is determined before release. If measured values meet authorized concentration limits, datum and volume released water is recorded. From released waters are prepared decant monthly samples and activity of activation and fission products is determined by gamma spectrometry. Half year decant samples are prepared as well and from which activity of strontium and transurans is determined by radiochemistry.

Determination of total activity of releases for given time scale is calculated from following analysis and parameters:

- Volume of released vater from control tanks,
- Activity of activation and fission products, see Tab. 13-21,
- tritium ^{3}H,
- strontium - $^{89+90}$Sr,
- transurans - ^{238}Pu, $^{239+40}$Pu, ^{241}Am.

From summary of year balance of given RN in liquid releases from EMO (according to PSR [I.33] in Tab. 13-21 for years 1998 -2007 and according to [I.12] in Tab. 13-22) is visible that also in this case the most representative radionuclides are ^{54}Mn, ^{110m}Ag, ^{60}Co.

Even ^{60}Co a ^{54}Mn were evidently increased in 2005, they were not always measurable in samples in 2006 – see Tab. 13-23, Balance value of ^{51}Cr is mostly value of MDA as well as other RN marked in table with star.

In spite of aerosols (releases into the atmosphere), activation and fission products are measurable in liquid releases: ^{137}Cs and ^{134}Cs and their percentage yield is at level of 8%.

Tab. 13-21 Balance of year RN activity in liquid releases from EMO12 in years 1998 - 2007 [MBq]

Effluents	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Avrg. 98-07	percent %	Cumm. release.
Cr-51	4,94	5,74	6,85	8,33	8,11	7,53	6,31	7,86	5,52	2,21	6,34	15,0*	0,02
Mn-54	8,67	12,1	2,14	11,0	2,33	1,90	4,45	3,50	1,10	0,98	4,82	11,4	2,5
Fe-59	1,28	1,56	1,12	1,60	1,35	0,58	0,50	1,43	1,05	0,39	1,09	2,59	0,03
Co-57	0,34	0,37	0,48	0,67	0,66	1,08	1,03	0,63	0,44	0,19	0,59	1,39	0,49
Co-58	1,27	3,23	0,66	3,44	1,36	1,37	1,20	2,33	0,80	0,67	1,63	3,89	0,14
Co-60	0,52	0,92	0,61	3,04	1,59	1,57	1,96	2,38	1,23	0,96	1,48	3,50	9,0
Zn-65	0,84	0,83	0,94	1,33	1,28	1,28	1,15	1,33	1,07	0,38	1,04	2,47	0,86
Zr-95	0,67	1,54	0,92	1,46	1,25	0,83	0,71	1,24	0,99	0,38	1,00	2,36	0,07
Nb-95	0,55	1,75	0,81	1,79	1,24	1,18	1,00	0,90	0,66	0,29	1,02	2,41	0,01
Ru-103	0,48	0,58	0,66	1,04	0,88	0,78	0,68	0,86	0,64	0,23	0,68	1,61	0,01
Rh-106	0,58	0,85	1,43	1,93	1,81	1,85	1,62	1,95	1,55	0,56	1,41	3,35	0,01
Ag-110m	0,46	0,74	0,63	3,67	2,98	3,93	7,30	18,18	5,75	1,81	4,55	10,8	6,0
Sb-124	1,28	2,77	1,17	11,3	1,07	1,74	0,66	3,46	0,81	0,36	2,46	5,84	0,06
I-131	2,36	5,41	20,5	4,63	2,69	2,31	2,01	2,51	1,34	0,56	4,43	10,5*	0,00
Cs-134	0,35	0,50	0,52	3,05	4,82	2,30	0,77	1,32	1,23	0,70	1,56	3,69	4,4
Cs-137	0,38	0,44	0,82	6,03	9,24	4,78	1,55	3,39	4,16	2,37	3,32	7,9	30,3
Ce-141	0,96	0,97	1,20	1,56	1,60	1,46	1,20	1,50	1,02	0,43	1,19	2,82	0,01
Ce-144	2,66	2,82	3,60	4,68	4,94	4,39	3,74	4,78	3,35	1,44	3,64	8,6*	3,6
Sum	28,6	43,2	45,0	70,6	49,2	40,9	37,8	59,5	32,7	14,9	42,2	100,0	57,47

Note:
Average and percentual composition of RN is influenced by MDA, which are included to the balance, if the RN was not measurable in the sample (from 2007 in accordance with last licence only half of MDA is included) – see Tab. 13-23. Therefore values of RN composition are only informative. The values marked with (*) are manly not measurable, but their high MDA considerably affect RN composition of liquid release.

Tab. 13-22 Balance of year RN activity in liquid releases from EMO12 in years 2008 - 2014 [MBq]

Rádionuclide	Jednotka	2008	2009	2010	2011	2012	2013	2014	A 2008-2014	%
H-3	GBq	7856	11450	9257	11440	12130	11870	10750	10679	100.00
Cr-51	MBq	1.86	2.40	2.05	1.85	2.17	2.14	1.64	2.02	0.00
Mn-54	MBq	0.62	1.23	0.67	0.58	0.52	0.45	0.93	0.71	0.00
Fe-59	MBq	0.34	0.46	0.40	0.39	0.43	0.40	0.30	0.39	0.00
Co-57	MBq	0.16	0.20	0.16	0.15	0.17	0.16	0.11	0.16	0.00
Co-58	MBq	0.58	1.34	0.94	0.39	0.89	0.53	0.59	0.75	0.00
Co-60	MBq	0.82	1.51	0.97	0.72	0.72	0.60	0.83	0.88	0.00

Rádionuclide	Jednotka	2008	2009	2010	2011	2012	2013	2014	A 2008-2014	%
Zn-65	MBq	0.33	0.44	0.39	0.37	0.41	0.37	0.18	0.35	0.00
Zr-95	MBq	0.31	0.41	0.34	0.35	0.35	4.54	4.56	1.55	0.00
Nb-95	MBq	0.23	0.28	0.23	0.29	0.28	17.27	4.03	3.23	0.00
Ru-103	MBq	0.20	0.26	0.22	0.21	0.24	0.34	0.22	0.24	0.00
Rh-106	MBq	0.49	0.63	0.56	0.53	0.61	0.35	0.25	0.49	0.00
Ag-110m	MBq	2.69	3.24	1.78	5.16	2.77	0.23	0.17	2.29	0.00
Sb-124	MBq	0.33	0.48	0.55	0.26	2.13	0.56	0.43	0.68	0.00
I-131	MBq	0.45	0.65	0.56	0.46	0.56	4.84	0.69	1.17	0.00
Cs-134	MBq	1.03	0.35	0.51	0.22	0.32	2.05	3.03	1.07	0.00
Cs-137	MBq	1.82	0.89	1.77	0.87	3.44	0.63	0.42	1.41	0.00
Ce-141	MBq	0.36	0.46	0.39	0.35	0.41	0.18	0.13	0.33	0.00
Ce-144	MBq	1.24	1.53	1.26	1.15	1.35	0.52	0.24	1.04	0.00
Sr-89	kBq	3.04	3.75	5.22	5.13	4.79	0.39	0.30	3.23	0.00
Sr-90	kBq	8.61	88.70	9.14	6.89	12.95	1.25	0.89	18.35	0.00
Pu-238	kBq	1.15	0.31	0.53	0.15	2.69	0.13	0.14	0.73	0.00
Pu-239+240	kBq	12.64	1.74	1.96	4.30	4.42	0.79	0.14	3.71	0.00
Am-241	kBq	0.74	0.50	3.19	0.74	0.43	0.41	0.14	0.88	0.00
SUM	**GBq**	**7856**	**11450**	**9257**	**11440**	**12130**	**11870**	**10750**	**10679**	**100**

Tab. 13-23 Comparison of RN balance at EMO12 NPP at dependence from MDA for liquid releases in 2006

Parameter		Bilancia s MDA	Bilancia bez MDA	Podiel %	Bilancia len z MDA	Podiel %
Trícium H-3	GBq	1,023E+04	1,023E+04	100,0%	1,967E-02	0,0%
Cr-51	MBq	5,518E+00	3,466E-02	0,6%	5,484E+00	99,4%
Mn-54	MBq	1,104E+00	7,766E-01	70,4%	3,270E-01	29,6%
Fe-59	MBq	1,049E+00	0,000E+00	0,0%	1,049E+00	100,0%
Co-57	MBq	4,421E-01	4,814E-03	1,1%	4,372E-01	98,9%
Co-58	MBq	8,021E-01	3,706E-01	46,2%	4,315E-01	53,8%
Co-60	MBq	1,229E+00	8,761E-01	71,3%	3,525E-01	28,7%
Zn-65	MBq	1,067E+00	0,000E+00	0,0%	1,067E+00	100,0%
Zr-95	MBq	9,863E-01	0,000E+00	0,0%	9,863E-01	100,0%
Nb-95	MBq	6,638E-01	8,698E-03	1,3%	6,551E-01	98,7%
Ru-103	MBq	6,431E-01	0,000E+00	0,0%	6,431E-01	100,0%
Rh-106	MBq	1,555E+00	0,000E+00	0,0%	1,555E+00	100,0%
Ag-110m	MBq	5,754E+00	5,554E+00	96,5%	2,004E-01	3,5%
Sb-124	MBq	8,057E-01	2,312E-01	28,7%	5,745E-01	71,3%
I-131	MBq	1,344E+00	0,000E+00	0,0%	1,344E+00	100,0%
Cs-134	MBq	1,233E+00	9,937E-01	80,6%	2,394E-01	19,4%
Cs-137	MBq	4,160E+00	4,052E+00	97,4%	1,078E-01	2,6%
Ce-141	MBq	1,019E+00	0,000E+00	0,0%	1,019E+00	100,0%
Ce-144	MBq	3,350E+00	2,451E-01	7,3%	3,105E+00	92,7%
Sr-89	kBq	6,361E+00	0,000E+00	0,0%	6,361E+00	100,0%
Sr-90	kBq	1,910E+01	1,910E+01	100,0%	0,000E+00	0,0%
Pu-238	kBq	1,550E+00	1,540E+00	99,4%	1,002E-02	0,6%
Pu-239+240	kBq	2,544E+00	2,544E+00	100,0%	0,000E+00	0,0%
Am-241	kBq	2,866E+01	2,866E+01	100,0%	0,000E+00	0,0%
Trícium H-3	GBq	1,023E+04	1,023E+04	100,0%	1,967E-02	0,0%
suma KaŠP	MBq	3,275E+01	1,317E+01	40,2%	1,958E+01	59,8%

The values of volumes released into atmosphere and hydrosphere for years 1998 – 2007 are given in Tab. 13-24.

Tab. 13-24 The values of volumes released into atmosphere and hydrosphere for years 1998 – 2014

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Liquid [m³]	2.48E+04	4.73E+04	5.33E+04	4.86E+04	4.66E+04	5.25E+04	4.38E+04	4.04E+04	2.22E+04	2.13E+04
Air [m³]	1.34E+09	2.46E+09	3.48E+09	3.74E+09	3.64E+09	3.78E+09	4.03E+09	4.10E+09	3.99E+09	4.50E+09
Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**			
Liquid [m³]	1,68E+04	1,87E+04	2.49E+04	1,80E+04	1,78E+04	1,62E+04	1,81E+04			
Air [m³]	4,43E+09	4,42E+09	4.55E+09	5.1E+09	5.18E+09	4,70E+09	4,76E+09			

Measured values of RN activity in environment samples are compared with reference levels determined in monitoring plan. These were exceeded only to a minimal extent, and when, so the action of external effects in NPP area. During the operation of Mochovce NPP there was not found out any case of measurable impact of the NPP on environment via atmospheric releases. Activities of ^{60}Co and ^{110m}Ag, which are typical RN for operation of given NPP, were always below the MDA in samples from environment.

This fact is confirmed also by very low level of RN releases into the atmosphere (according to measured long time balance values of releases into atmosphere via ventilation stack). Exception of measurability of Mochovce NPP impact on environment is Hron river hydrosphere under pipeline collectorostomy. Measured RN are on very low and radiohygienically negligible level. Sometimes there were measured RN typical for operation of NPP and this pathway of releases (^{3}H, ^{60}Co, ^{110m}Ag and others activation products).

The measured values refer to background levels of radioactivity in individual components of environment originating from external sources, as: natural background, global deposit from nuclear weapons tests, Chernobyl NPP accident.

Radioactivity from external sources is detailed described in chapter 4.8 of this POSAR [I.29].

13.1.4.4 Evaluation of the doses to population from operation of EMO12 untill now

For the evaluation of the impact of NPP EMO operation to the population in the surrounding environment, analyse of the exposure of population is provided once a year. Such analyse is provided **on the basis of real releases** of the radioactive substances into atmosphere and hydrosphere.

The gaseous radioactive substances are releases into atmosphere via ventilation stack. The data on meteorological situation are gained from meteorological station placed in EMO site. The wind rose in 2014 [I.12], i.e. the graphic expression of the wind direction frequency is drawn in the Fig. 13-9. Except of this data, the newest data from Slovak hydrometeorological institute are available. The liquid radioactive substances are released into hydrosphere via pipeline collector to the Hron River below the dam of the reservoir in Kozmálovce. The river is exploited for recreation reasons as well as for irrigation.

From the calculation provided by RDEMO program it results, that the area with highest values of the annual individual effective dose and, the 50(70) years commitment of collective effective dose are situated in the direction East-South-East and in the direction North-West of EMO site in the direction of the prevailing winds and in the direction of the Hron River – Fig. 13-10. Permanently settled zone with the highest value of annual individual effective dose calculated from the actual releases is in the distance of 3 to 5 km (zone 64) and in direction East-South-East of EMO NPP. The village of Nový Tekov is situated in this sector.

The calculation of individual effective dose (IED) results for the given zone (zone 64) for different categories of age in 2014 are expressed in the Tab. 13-25 and on the Fig. 13-11. The critical exposition pathways for radiation load for individual from this zone is the hydrosphere – namely the exposition from the ingestion of contaminated drinking water with dominant radionuclide of Tritium with the share of 90,5 percent on the individual effective dose. The values of annual individual effective doses of the population of Nový Tekov village from start-up of EMO12 into operation are shown on the Fig. 13-12, Fig. 13-13, Tab. 13-25 and Tab. 13-27. For comparision, in the Tab. 13-26 are presented results for zone 78 (Kalna nad Hronom), where maximal IED were calculated according to values of designed effluents. The results of the calculation of the burden of collective effective dose in all zones and from the NPP EMO start-up till the year 2014 are shown on the Fig. 13-14.

On the basis of the mentioned facts it is possible to express that the highest value of annual individual effective dose in 2014 was calculated in the locality of Nový Tekov and reached:

- For infants 0,143 μSv
- For adults 0,117 μSv

The value of 0,143 μSv creates 0,06% of the authorised annual limit 250 μSv for an individual from the population established in the Act 87/2018 Coll., respectively 0,3% of 50 μSv radiological target for MO34. Main contribution is from hydrosphere (97,6%). Tha maximum exposition pathway for dose burden of individual person is exposition from ingestion of contaminated water (83,7% with dominant radionuclide ^{3}H). For atmosphere dose burden is the most important ingestion from foods contaminated by atmospheric fallout (2,2% fraction of exposition pathway) with dominant RN ^{14}C.

According to the Act No 87/2018 Coll. [II.5] , it is not necessary to prove the radiation protection optimization before start of activity leading to the irradiation in the cases when for the activity is proved that year effective dose for each worker will not exceed one mSv and year effective dose for no one of population will not exceed 10 μSv.

The value of the collective effective dose commitment for the whole region was calculated for real RN releases into the atmosphere and hydrosphere during 2014 for whole population of this region (with population approx. 1,2 million) as 7,85 man mSv.

The results of the radiological impact of the releases to the environment are presented in the Tab. 13-27 and in the Fig. 13-12, Fig. 13-13 and Fig. 13-14. Presented values of the radiological impact are taken up from [I.12] and [I.53]. The calculated values of the annual individual equivalent dose increase gradually for the locality of Nový Tekov from the year 1998 for the age group of infants from 0,1 μSv through 0,38 μSv to about 0,56 in 2005. From 2006 to 2010 update of input data occurred and individual effective doses were within interval (0.06 - 0.18) μSv. This decrease is related to the updating of the data entering the calculation. For the category of adults, the similar values increase from 0,07 μSv, up to 0,3 μSv (2005). From 2006 to 2010 values varied within interval of (0,05 - 0.14) μSv. The value of the collective effective dose commitment increases gradually for the age group of adults from 0,049 manmSv through 0.155 manmSv to approximally 0.230 manmSv. Between years 2006 and 2010 collective effective dose ranges between 0.035 and 0.105 manmSv. After updating relevant data this value decreased to 0.04 manmSv in 2010, nowadays it is at level around 0,05 man.mSv. The results show, that the value of the released Tritium in the liquid releases has the dominant impact to the values of Individual effective dose and collective effective dose commitment during NPP normal operation.

The value of the collective effective dose commitment in whole region increased from the value of 3,63 man mSv, trough 16,83 manmSv to less than 30 manmSv. From 2006 the values were significantly lower (update of input data). In 2010 it was 4,21 manmSv, nowadays it is around 6-8 man.mSv.

The differences in the radiological consequences of the actual releases from EMO12 operation till to now, in the comparison with design based values of releases from EMO NPP are caused by the fact, the actual releases from EMO12 ventilation stack is only small fraction from reference based levels. In this context, the critical pathway is the hydrosphere and the critical group of population is citizen of the Nový Tekov village. The significant difference of the values of actual releases against the design based values is given before all by the good quality of the fuel elements cladding and only exceptionally occurrence of un-tightness.

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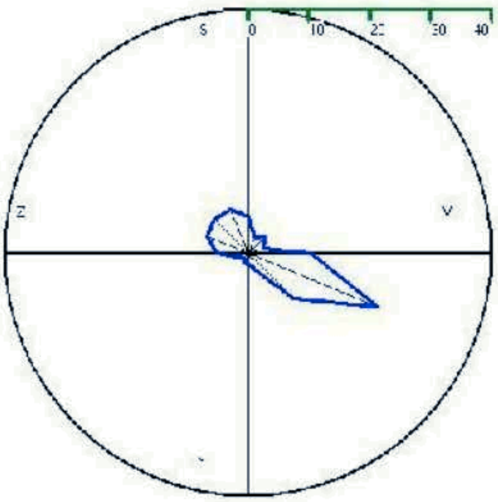

Smer vetra		%	Početnosť
Sever S	S	6.10	532
Severo-severovýchod SSV	SSV	3.12	272
Severovýchod SV	SV	4.05	353
Východo-severovýchod VSV	VSV	2.63	229
Východ V	V	10.35	903
Východo-juhovýchod VJV	VJV	23.10	2015
Juhovýchod JV	JV	10.79	941
Juho-juhovýchod JJV	JJV	3.28	286
Juh J	J	1.97	172
Juho-juhozápad JJZ	JJZ	1.89	165
Juhozápad JZ	JZ	1.57	137
Západo-juhozápad ZJZ	ZJZ	2.04	178
Západ Z	Z	5.34	466
Západo-severozápad ZSZ	ZSZ	7.43	648
Severozápad SZ	SZ	8.23	718
Severo-severozápad SSZ	SSZ	8.14	710
Bezvetrie CALM	CALM	0.00	0

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Fig. 13-9 Characteristic wind rose on the Mochovce site in 2014

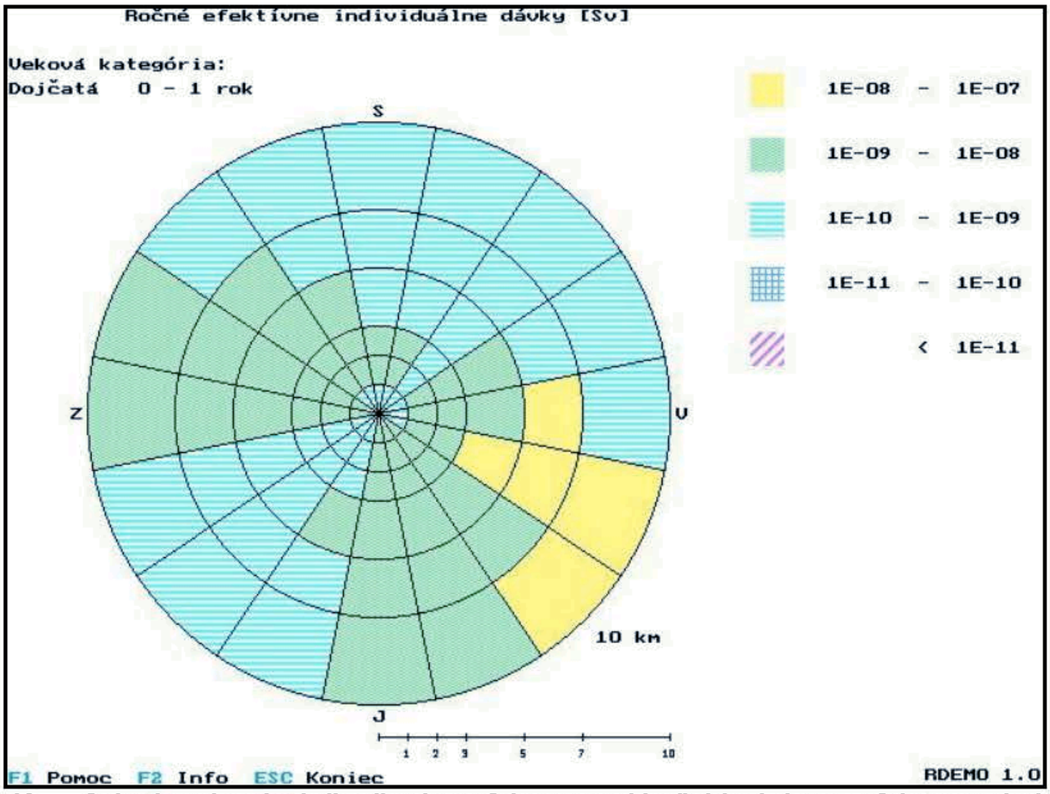

Fig. 13-10 Calculated typical distribution of the annual individual doses of the population in the EMO environment

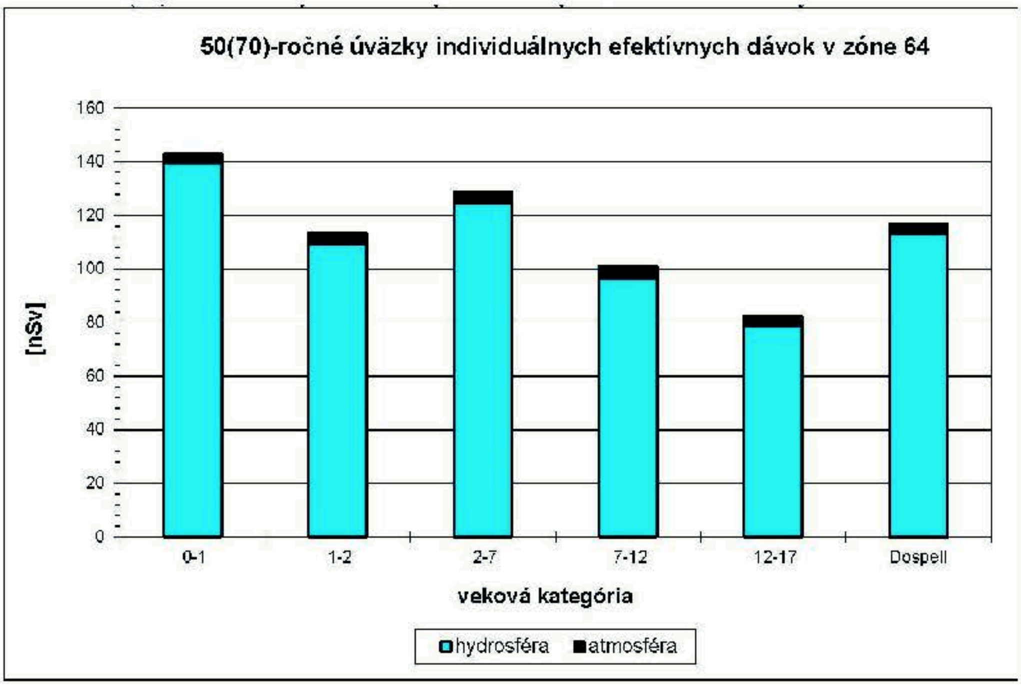

Fig. 13-11 Calculated distribution of individual effective doses for zone No 64 in 2014 for different age groups

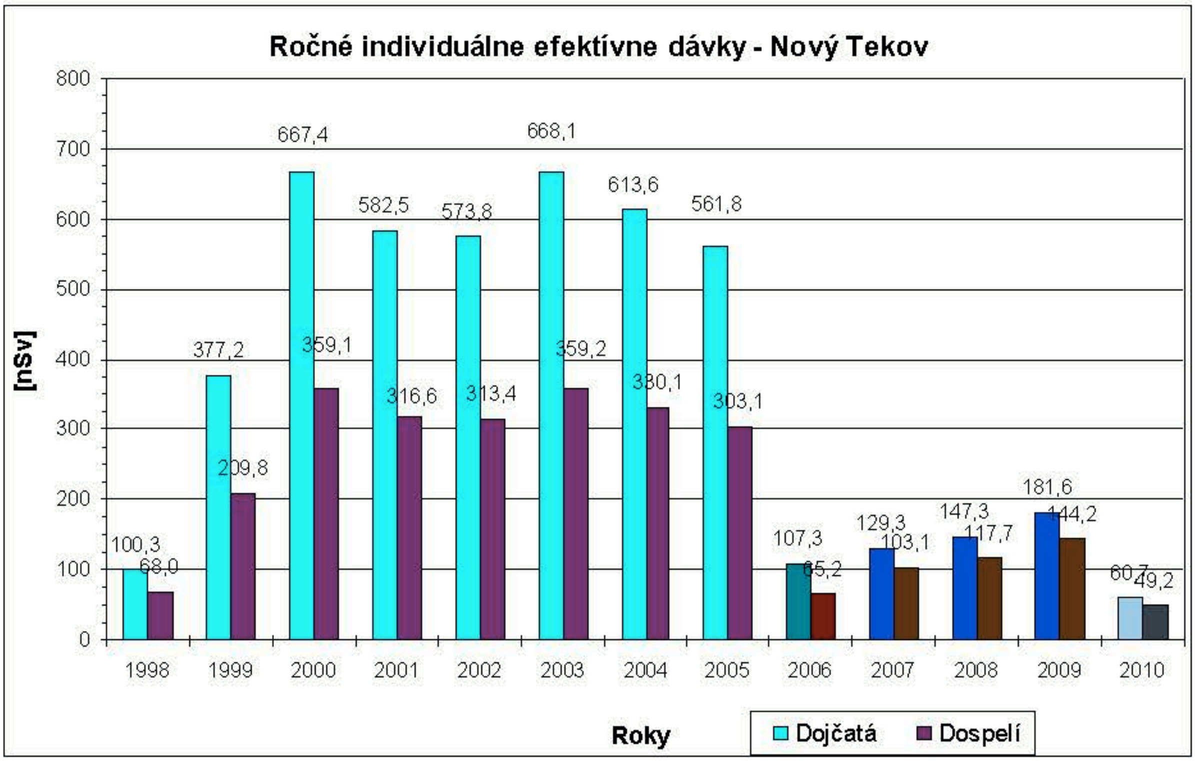

Fig. 13-12 Calculated annual individual effective doses for population of Nový Tekov from EMO12 start - up

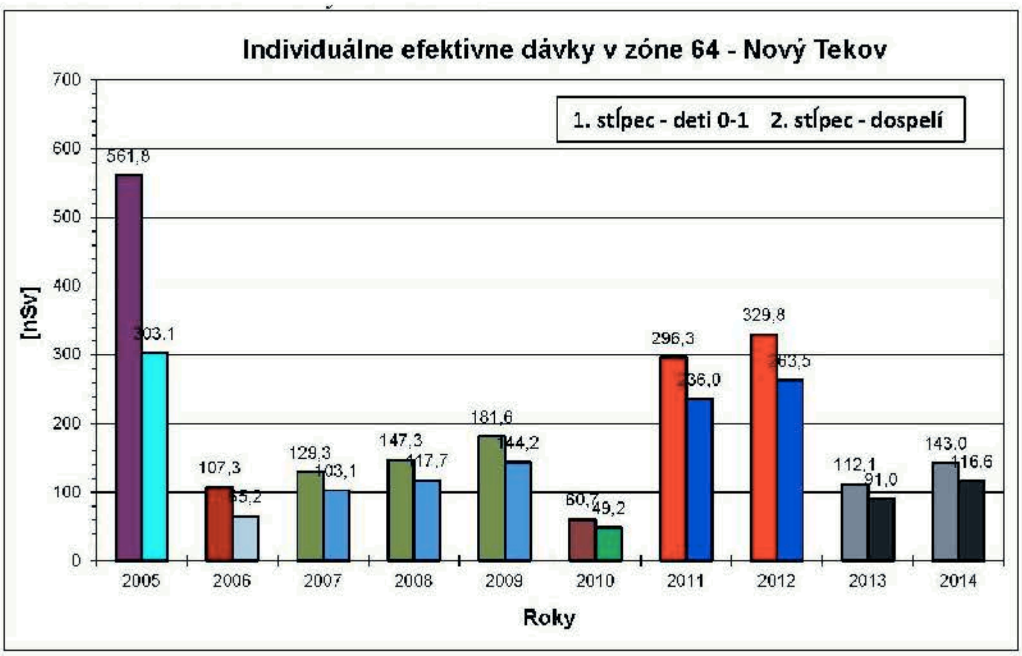

Fig. 13-13 Calculated annual IED for population of Novy Tekov 2005 - 2014

Tab. 13-25 50(70)-year IED burden from radionuclides for age groups in zone 64 (Novy Tekov) in 2014

Radionuclide	0-1	1-2	2-7	7-12	12-17	Adults
H 3	1.32E-07	1.02E-07	1.17E-07	8.90E-08	7.11E-08	1.06E-07
C 14	2.67E-09	3.56E-09	3.71E-09	3.64E-09	2.87E-09	2.88E-09
AR 41	2.38E-10	2.38E-10	2.38E-10	2.38E-10	2.38E-10	2.38E-10
CR 51	5.76E-12	5.74E-12	5.73E-12	5.71E-12	5.69E-12	5.70E-12
MN 54	9.57E-11	9.54E-11	9.54E-11	9.53E-11	9.51E-11	9.56E-11
FE 59	3.00E-11	2.99E-11	2.99E-11	2.99E-11	2.99E-11	3.03E-11
CO 57	7.45E-12	7.43E-12	7.43E-12	7.42E-12	7.41E-12	7.42E-12
CO 58	8.06E-11	8.04E-11	8.04E-11	8.02E-11	8.01E-11	8.03E-11
CO 60	7.67E-09	7.67E-09	7.67E-09	7.67E-09	7.66E-09	7.65E-09
ZN 65	6.67E-12	6.04E-12	6.02E-12	5.83E-12	5.63E-12	6.73E-12
AS 76	5.98E-15	9.60E-15	9.29E-15	8.63E-15	7.32E-15	6.74E-15
SE 75	4.21E-13	4.22E-13	4.34E-13	4.00E-13	2.47E-13	2.11E-13
KR 85M	2.13E-13	2.13E-13	2.13E-13	2.13E-13	2.13E-13	2.13E-13
KR 85	2.21E-13	2.21E-13	2.21E-13	2.21E-13	2.21E-13	2.21E-13
KR 87	3.76E-12	3.76E-12	3.76E-12	3.76E-12	3.76E-12	3.76E-12
KR 88	1.02E-11	1.02E-11	1.02E-11	1.02E-11	1.02E-11	1.02E-11
SR 89	1.90E-14	1.03E-14	8.91E-15	6.16E-15	4.38E-15	4.34E-15
SR 90	4.55E-13	1.52E-13	1.54E-13	2.39E-13	3.75E-13	1.52E-13
ZR 95	4.70E-12	4.69E-12	4.69E-12	4.67E-12	4.67E-12	4.67E-12
NB 95	9.78E-14	1.00E-13	9.82E-14	9.65E-14	9.64E-14	1.55E-13
RU 103	6.70E-13	6.71E-13	6.66E-13	6.60E-13	6.54E-13	6.61E-13
RU 106	4.08E-14	4.25E-14	3.20E-14	2.75E-14	2.11E-14	2.01E-14
RH 106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AG 110M	5.20E-12	4.51E-12	4.40E-12	4.03E-12	3.72E-12	4.20E-12
SB 122	4.48E-16	4.92E-16	4.40E-16	3.87E-16	3.05E-16	2.83E-16
SB 124	8.56E-12	8.57E-12	8.41E-12	8.33E-12	8.24E-12	9.28E-12
I 131O	1.71E-13	5.79E-13	5.63E-13	3.28E-13	2.08E-13	1.16E-13
I 131A	2.25E-14	4.96E-14	5.57E-14	3.89E-14	3.16E-14	2.08E-14
I 131E	1.49E-11	1.59E-11	1.58E-11	8.70E-12	5.69E-12	9.27E-12
I 132O	4.94E-14	6.05E-14	6.53E-14	5.58E-14	5.30E-14	4.82E-14
I 132A	4.52E-14	6.69E-14	7.13E-14	5.38E-14	4.90E-14	3.97E-14
I 133O	1.46E-14	2.55E-14	2.57E-14	1.72E-14	1.47E-14	1.05E-14
I 133A	1.79E-14	3.20E-14	3.51E-14	2.30E-14	1.95E-14	1.34E-14
XE 133M	8.89E-14	8.89E-14	8.89E-14	8.89E-14	8.89E-14	8.89E-14
XE 133	1.52E-13	1.52E-13	1.52E-13	1.52E-13	1.52E-13	1.52E-13
XE 135	6.95E-13	6.95E-13	6.95E-13	6.95E-13	6.95E-13	6.95E-13
CS 134	5.39E-11	5.36E-11	5.38E-11	5.40E-11	5.45E-11	6.04E-11
CS 137	2.04E-12	1.16E-12	1.52E-12	1.96E-12	2.81E-12	1.02E-11
CE 141	2.91E-12	2.89E-12	2.89E-12	2.88E-12	2.87E-12	2.88E-12
CE 144	2.25E-11	2.20E-11	2.16E-11	2.13E-11	2.10E-11	2.13E-11
HF 181	1.04E-14	1.06E-14	9.48E-15	8.66E-15	7.91E-15	7.57E-15

Radionuclide	0-1	1-2	2-7	7-12	12-17	Adults
PU 238	8.10E-14	6.91E-14	7.12E-14	7.24E-14	7.50E-14	1.13E-12
PU 239	2.75E-14	2.12E-14	2.24E-14	2.33E-14	2.46E-14	6.03E-13
PU 240	4.85E-14	4.22E-14	4.34E-14	4.42E-14	4.56E-14	6.18E-13
AM 241	1.46E-13	1.35E-13	1.37E-13	1.38E-13	1.41E-13	1.17E-13
Hydrosphere	1.40E-07	1.09E-07	1.24E-07	9.65E-08	7.87E-08	1.13E-07
Atmosphere	3.40E-09	4.28E-09	4.46E-09	4.37E-09	3.56E-09	3.59E-09
Sum	1.43E-07	1.13E-07	1.29E-07	1.01E-07	8.22E-08	1.17E-07

Tab. 13-26 50(70)-year IED burden from radionuclides for age groups in zone 78 (Kalna nad Hronom) in 2014

Radionuclide	0-1	1-2	2-7	7-12	12-17	Adults
H 3	1.32E-07	1.01E-07	1.17E-07	8.88E-08	7.09E-08	1.05E-07
C 14	1.76E-09	2.35E-09	2.45E-09	2.41E-09	1.89E-09	1.90E-09
AR 41	1.03E-10	1.03E-10	1.03E-10	1.03E-10	1.03E-10	1.03E-10
CR 51	5.76E-12	5.73E-12	5.72E-12	5.70E-12	5.68E-12	5.69E-12
MN 54	9.55E-11	9.51E-11	9.52E-11	9.50E-11	9.49E-11	9.54E-11
FE 59	2.99E-11	2.99E-11	2.99E-11	2.99E-11	2.99E-11	3.03E-11
CO 57	7.45E-12	7.43E-12	7.43E-12	7.42E-12	7.41E-12	7.42E-12
CO 58	8.05E-11	8.02E-11	8.03E-11	8.01E-11	8.00E-11	8.02E-11
CO 60	7.67E-09	7.66E-09	7.66E-09	7.66E-09	7.66E-09	7.65E-09
ZN 65	6.60E-12	5.99E-12	5.97E-12	5.78E-12	5.59E-12	6.69E-12
AS 76	3.67E-15	5.98E-15	5.80E-15	5.39E-15	4.56E-15	4.19E-15
SE 75	2.28E-13	2.28E-13	2.35E-13	2.17E-13	1.34E-13	1.14E-13
KR 85M	1.01E-13	1.01E-13	1.01E-13	1.01E-13	1.01E-13	1.01E-13
KR 85	1.19E-13	1.19E-13	1.19E-13	1.19E-13	1.19E-13	1.19E-13
KR 87	1.57E-12	1.57E-12	1.57E-12	1.57E-12	1.57E-12	1.57E-12
KR 88	4.58E-12	4.58E-12	4.58E-12	4.58E-12	4.58E-12	4.58E-12
SR 89	1.89E-14	1.02E-14	8.86E-15	6.12E-15	4.35E-15	4.32E-15
SR 90	3.99E-13	1.34E-13	1.36E-13	2.10E-13	3.29E-13	1.35E-13
ZR 95	4.68E-12	4.67E-12	4.67E-12	4.66E-12	4.65E-12	4.65E-12
NB 95	7.64E-14	7.79E-14	7.66E-14	7.55E-14	7.54E-14	1.35E-13
RU 103	6.69E-13	6.69E-13	6.65E-13	6.59E-13	6.53E-13	6.60E-13
RU 106	2.23E-14	2.34E-14	1.78E-14	1.53E-14	1.17E-14	1.11E-14
RH 106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AG 110M	4.16E-12	3.47E-12	3.38E-12	3.02E-12	2.72E-12	3.21E-12
SB 122	2.58E-16	2.87E-16	2.59E-16	2.28E-16	1.78E-16	1.64E-16
SB 124	8.54E-12	8.54E-12	8.39E-12	8.31E-12	8.22E-12	9.26E-12
I 131O	8.69E-14	2.93E-13	2.86E-13	1.67E-13	1.06E-13	5.92E-14
I 131A	1.50E-14	3.24E-14	3.66E-14	2.58E-14	2.11E-14	1.39E-14
I 131E	1.49E-11	1.58E-11	1.58E-11	8.67E-12	5.68E-12	9.25E-12
I 132O	2.43E-14	3.04E-14	3.30E-14	2.78E-14	2.63E-14	2.37E-14
I 132A	2.40E-14	3.66E-14	3.91E-14	2.90E-14	2.61E-14	2.07E-14
I 133O	8.03E-15	1.41E-14	1.43E-14	9.59E-15	8.18E-15	5.83E-15

Radionuclide	0-1	1-2	2-7	7-12	12-17	Adults
I 133A	1.19E-14	2.13E-14	2.33E-14	1.52E-14	1.29E-14	8.87E-15
XE 133M	4.72E-14	4.72E-14	4.72E-14	4.72E-14	4.72E-14	4.72E-14
XE 133	8.13E-14	8.13E-14	8.13E-14	8.13E-14	8.13E-14	8.13E-14
XE 135	3.47E-13	3.47E-13	3.47E-13	3.47E-13	3.47E-13	3.47E-13
CS 134	5.39E-11	5.35E-11	5.37E-11	5.40E-11	5.44E-11	6.03E-11
CS 137	1.99E-12	1.14E-12	1.49E-12	1.92E-12	2.76E-12	1.01E-11
CE 141	2.91E-12	2.89E-12	2.89E-12	2.87E-12	2.87E-12	2.88E-12
CE 144	2.24E-11	2.20E-11	2.16E-11	2.13E-11	2.10E-11	2.12E-11
HF 181	5.74E-15	5.90E-15	5.31E-15	4.84E-15	4.40E-15	4.20E-15
PU 238	8.00E-14	6.80E-14	6.94E-14	7.04E-14	7.24E-14	1.13E-12
PU 239	2.70E-14	2.06E-14	2.15E-14	2.21E-14	2.32E-14	6.01E-13
PU 240	4.79E-14	4.16E-14	4.24E-14	4.31E-14	4.41E-14	6.16E-13
AM 241	1.45E-13	1.34E-13	1.35E-13	1.36E-13	1.38E-13	1.14E-13
Hydrosphere	1.40E-07	1.09E-07	1.24E-07	9.65E-08	7.87E-08	1.13E-07
Atmosphere	2.14E-09	2.72E-09	2.84E-09	2.78E-09	2.25E-09	2.26E-09
Sum	1.42E-07	1.12E-07	1.27E-07	9.93E-08	8.09E-08	1.15E-07

Tab. 13-27 Radiological impact of the releases of radioactive substances from EMO12 in years 1998 to 2014

	% of the radiological target 50 µSv	Annual Individual effective dose Zone No 64 [µSv]		Collective effective dose commitment	
				Zone No 64 [manmSv]	All zones [manmSv]
Year	Infants	Infants	Adults	Adults	Total
1998	0.20%	0,100	0,068	0,05	3,63
1999	0.75%	0,377	0,210	0,155	16,83
2000	1.35%	0,667	0,359	0,263	28,75
2001	1.15%	0,582	0,317	0,243	26,71
2002	1.15%	0,574	0,313	0,240	26,41
2003	1.35%	0,668	0,360	0,269	29,64
2004	1.25%	0,614	0,330	0,246	27,16
2005	1.10%	0,562	0,303	0,229	25,22
2006	0.22%	0,107	0,065	0,049	5,36
2007	0.26%	0,129	0,103	0,078	8,33
2008	0.30%	0,147	0,118	0,086	9,33
2009	0.37%	0,182	0,144	0,106	11,47
2010	0.12%	0,061	0,049	0,035	4,21
2011	0,59%	0,296	0,236	0,162	18,68
2012	0,66%	0,330	0,264	0,181	20,91
2013	0,22%	0,112	0,091	0,050	6,16
2014	0,29%	0,143	0,117	0,058	7,85

Note: *The increase in the first years from the start of operation coheres with the stepwise start-up of individual reactor units. It is possible to consider, that the EMO12 NPP is operated on stable power parameters from the year 2000.*

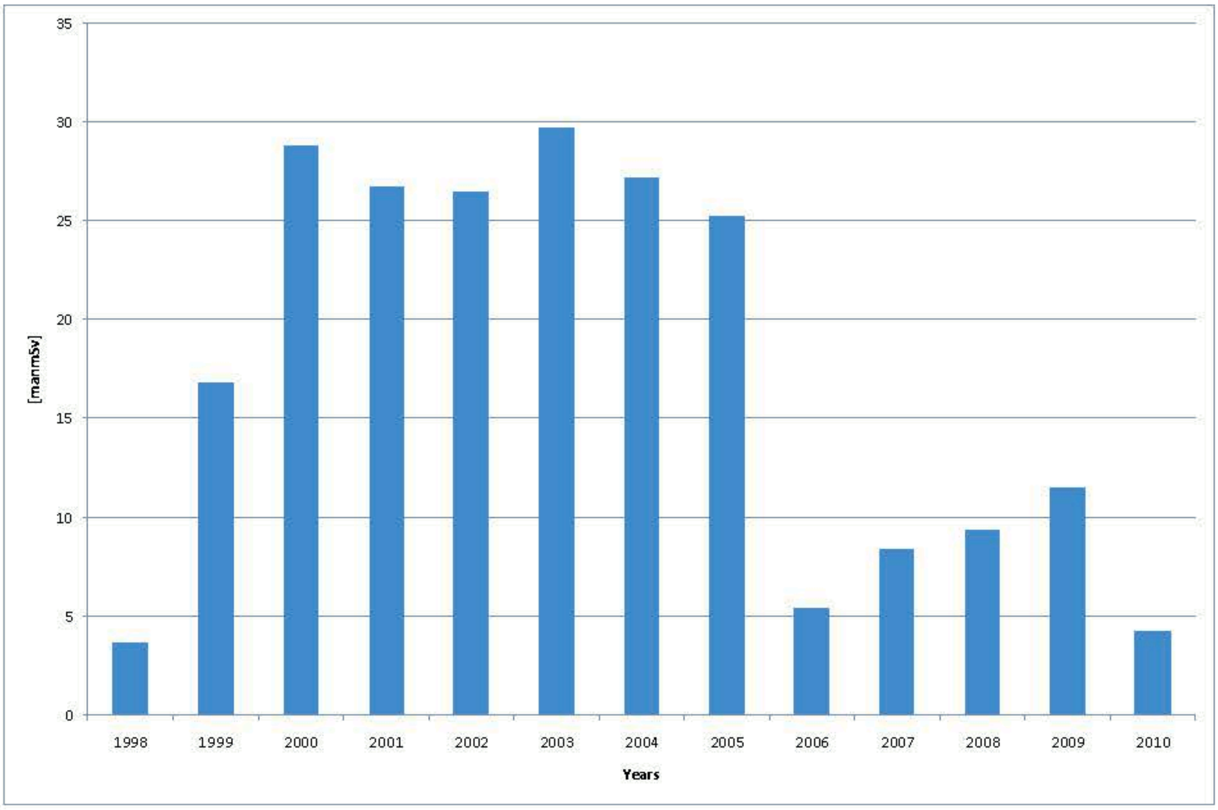

Fig. 13-14 **Calculated collective effective dose commitments in all zones from EMO12 start-up until 2010**

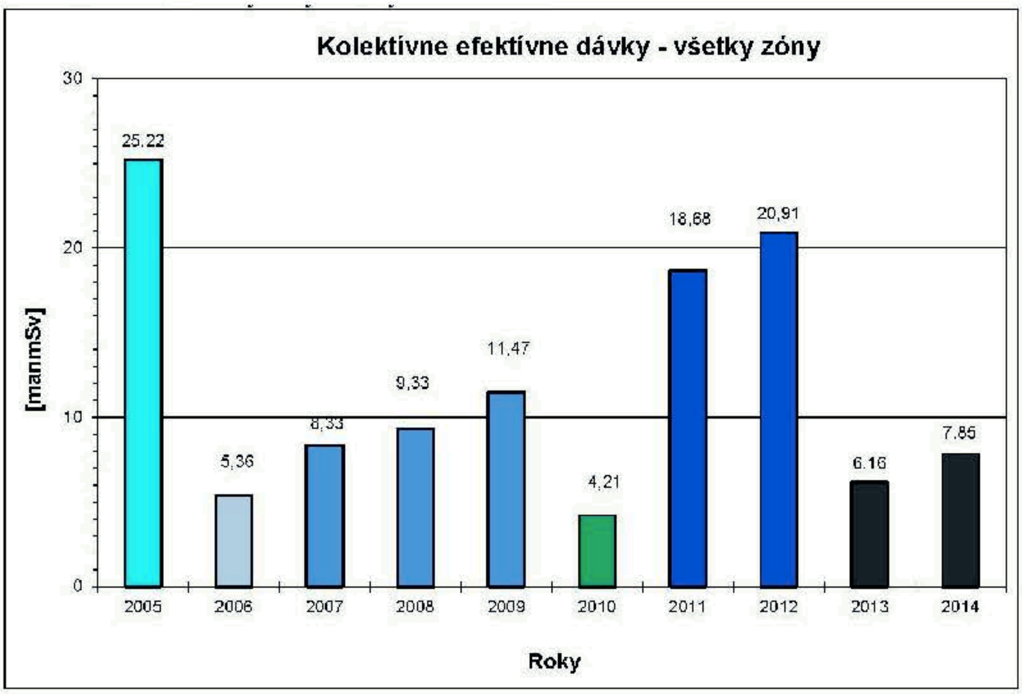

Fig. 13-15 Calculated collective effective dose commitments in all zones 2005-2014

Note to the figures Fig. 13-9 - Fig. 13-15:

- Years1998-2005: used initial data for RDEMO
- Year 2006: updated conversion factors for ingestion and inhalation for 6 age groups and efective dose, amount of breathed air in accordance with [II.5]. Instead of minimum flow rate in Hron river (6,6 $m^3.s^{-1}$) was used used the average ammual value of water flow rate in Hron river during discharge of controll tanks from system PWT3 (ŠOV3) with Tritium content. From analysis of individual changes follows that in previous years was calculation of radiologcal influence too conservativly overestimated.
- Year 2007: in accordance with the decision of the PHA SR on discharge of radioactive substances and assessing the impact of radioactive discharges of radionuclides, new radionuclides were included ^{46}Sc, ^{75}Se, ^{122}Sb, ^{181}Hf, ^{133}I together with the appropriate constant to the input data files of RDEMO program. Further, data on meteorological situation in the EMO12 site were for the years 1988-2006 obtained from the Slovak Hydrometeorological Institute Bratislava, meteorological station Mochovce. Meteorological data from 2007 were obtained from the meteorological station situated at the Mochovce NPP site - wind direction and speed category and stability of the system SODAR level of 150 m (height ventilation stack) and rainfalls. Values of ingested water were changed for different age groups according to Ministry of Health Decree no. 545/2007. Changes in input data are reflected in the increase in annual effective dose for an individual from the critical group of population.
- Years 2008-2009: updated real value of flow rate in Hron river
- Year 2010: updated shieldings factors for cloud and fallouts and residence time on irrigated land. Age composition of population and number of population in zone 64 was updated. Flow rate in Hron river was updated
- Since 2011: change in the way the radiological impact of the individual from the critical population - from an annual individual effective dose to 50(70) commitment individual effective dose.
- Since 2013 RDEMO is used version 3.5. Data in databases and calculation--acetic models were updated.

13.1.5 Report of the radiological impacts of the EMO operation to the living environment

The presentation of the evaluation of the MO34 operation impact to the living environment is provided by the EMO12 (where the similar impact on the environment is supposed and which are send to respective authorities - NRA SR and PHA SR) annual reports. The report labelled "**Report on situation on the radiological safety in relevant year**" presents the situation on radiological safety on NPP site; the balance of the activity of radionuclides in the gaseous effluents (released via the ventilation stack) and in the liquid releases (disposed via the pipeline channel to the Hron River). This report developed by the department of radiological protection provides the complex image of individual working places with the sources of ionising radiation in the competence of EMO12 and with the relevant valid license of PHA SR. The aim of the report is to evaluate the radiological protection on such working places and, eventually to propose the correction measures for elimination of undesirable situation. The same influence on environment is expected from MO34 like from EMO12.

In the report labelled "**Summary report on releases of radioactive substances from EMO12 and on the radiological impact of these releases to the environment**" [I.12], there are assigned the results of the monitoring of the radioactive releases from EMO site into atmosphere and hydrosphere in the actual year as well as the comparison with limits established for NPP units by PHA SR in relevant decision. Beside them, the report involves also the evaluation of the radiological impact of these releases to the environment in the actual year. Such evaluation of the impact of EMO NPP to the surrounding population is provided on the basis of exposure analyse of the surrounding population calculated for actual releases of radioactive substances into the atmosphere and hydrosphere during the actual year. For the reason of the calculation, the area around EMO NPP with semi-diameter of 60 km was divided into 16 sectors and 12 annulus, i.e.192 zones.

Beside them, the report labelled "**Report on radioactivity monitoring in the environment of EMO**" is issued annually and presents the result of the monitoring of the impact of NPP operation on the individual components of the living environment. The report is developed and issued by the LRKO and TDS department in Levice. In this report, the actualised monitoring program for the relevant year and all results of monitoring are involved (direct measurement of the radiological characteristics in field and the results acquired on the basis of the samples taking of the living environment and the laboratory evaluation of these samples in LRKO).

Data from the mentioned reports for individual years of EMO12 operation (reference NPP for MO34) were used for development of this part of the chapter 13 – and are namely involved in the Chapter 13.1.4.

13.1.6 Conclusion of radiological impacts

On the basis of data from reference NPP EMO12 it was considered the impact of MO34 on the environment.

Dose burden to population was evaluated on the basis of RN balance in EMO12 releases. The dose burden is many orders below tha authorized limits. The balance RN values in releases were also on very low level.

It is possible to say, that impact of reference NPP EMO12 operation was not proved (demonstrated) by the measurements in elements of environment (nowhere was measured ^{54}Mn, ^{110m}Ag and ^{60}Co, which are the main indicators of impact from NPP EMO12 operation). The indicator radionuclides were always below the detection limit of used measurement methods. Contemporary measurement methods are not enough sensitive for evaluation of MO34 infuence on the environment and therefore it is necessary to use calculation code.

Deterministic calculation code RDEMO v.3.5 is to be used for evaluation of radiological consequencies of radioactive effluents into atmosphere and hydrosphere (ventilationa stack of EMO and Hron river via piping collector) during normal operation. The code is very conservative in comparison with reality. The conservatism can be summarized as follows:

- In zone influenced by hydrosphere the code takes into the account ingestion of drinking water only from wells influenced by direct water leakage from contaminante water (no retention of RN in soil is considered). It means the same as inhabitants in the surroundings drink water directly and only from this river (liquid income from other noncontaminated sources like other wells, packed bottles, etc. were not considered),
- Ingestion - income of local foodstuff only is considered contaminated by atmospheric fallout and irrigations - inhabitants do not eat imported foodstuff, it means that all consumed foodstuff is contaminated.

The presented conservative approaches significantly overestimate calculation of effective doses for representative person from the critical group of the population and this overestimation is possible to quantify at level of few times up to one order of magnitude. In chapter 13.1.2.1.1 are presented calculation results for normal operation, whereas maximum it means annual refrence levels of effluents into atmosphere and hydrosphere are considered. In spite of above mentioned connservative approach, it has been proved that maximum contribution to committed effective dose for representative person from the critical group of the population is at level of two orders of magnitude lower as limit value (50 µSv/year).

13.1.7 Selected programs of environmental monitoring and warning systems which shall respond on unexpected leakages of radioactive substances

The environmental monitoring programms and warning systems are assured in sufficient scope for early response and thereby prevention or minimization of unexpected leakages of radioactive substances. All significat environmental components and possible leakage pathways are covered.

The monitoring programms are ensured by radiation monitoring systems of NPP operation, ensuring the monitoring of barier tightness and not exceeding of authorized limits for gaseous and liquid discharges, as well as the external regime monitoring of NPP surrounding by LRKO and TDS. These systems includes technical monitoring means, monitoring results transfer and recording system as well as set of organizational measures defined in respective operational presciption and monitoring plans. Following monitorong programs are ensured by unit of radiation monitoring of operation and unit of LRKO and TDS:

- Teledosimetry system - TDS
- Program of environmental component monitoring by sampling
- Termoluminiscnce dosimetry grid
- Continual and balance monitoring af gasseous dischages troughout ventilation stack
- Continual and balance monitoring af liquid discharges
- Monitoring technology processes

Teledozimetrický systém - TDS

TDS purpose is to provide early indication of deviations from normal operating conditions or as well emergency situations directly in the environment of EMO surrounding and to thus react to unexpected releases of radioactive matters from MO34. TDS is described in more detail in Chaptep 04.08 of this POSAR [I.29].

Intervention measure in case of elevated level of gamma dose rate in TDS is that fast mobile group makes more accurate radiation situation in places with increased level and give a report to head of LRKO group and TDS, head of radiation protection unit and then to shift supervisor. Potential warning of population is competence of shift supervisor, who acts in accordance with on-site emergeny plan [I.52].

After revealing of potential source of leakages from any system of NPP monitoring is focused on given system. Radiation control provides more sensitive and detailed information about the leakage in comparison to measurements of the environment. The goal is the fastest indentification of causes and minimization of leakages into the environment in accordance to compliance of respective limits and conditions as well as ALARA principle

Program of environmental component monitoring by sampling

Purpose of the program is to monitor radiation situation in NPP surroundings by sampling and periodic measurements during normal operation as well as during situations linked with leakages of radioactive substances into the environment. Sampling of specimen and following laboratory analysis are anesuerd within approved monitoring plan. Subprograms for monitoring of environmental components are more detailed described in Monitoring plan of radiation control of EMO surroundings [I.14] and in chapter 13.1.3.2 of this POSAR. Monitoring outside of NPP is ensured by LRKO and TDS.

For all monitored quantities are introduced reference levels whose exceeding is signal for investigation of causes. Investigation includes control of sampling proces, samples treatment and measurement as well as new sampling and new measurement. Aim of investigation is to determine reasons of reference level exceeding and to decide if it was caused by NPP operation. Reference levels are determined individualy for monitored quantities, kind of samples and place of sampling. Worker who reveals exceeding of reference level shall notify head of the group who will inform head of radiation protection unit to ensure feedback. Summary of investigation levels is in [I.14].

Reference levels of environmental samples analyzed are practically very low background levels RN content. It should be noted that being exceeded does not necessarily mean an increased risk of radiological exposure of the population. The signals at these low levels are under investigation mainly because of the causes leading to the development of a possible accident, or increased leakage during normal operation can be identified as soon as possible and stopped and potential leakage can thus be minimized in accordance with the ALARA principle.

Termoluminiscnce dosimetry grid - TLD

Termoluminisce dosimeter serves for determination of total integrated dose at given place during the normal operation and in case of radiation situation and therefore is ensured monitoring of personal doses of population in surroundings of NPP. Dense grid and long period of measurement makes this system very sensitive. Downside is in long response time, which disables to use TLD for operational purposes. In case of elevated values the procedure is the same as in case of monitoring of environmental samples.

Continual and balance monitoring af gasseous dischages troughout ventilation stack

By this system is ensured not exceeding of annual reference level of discharges. Volumic activity of noble gases, aerosols and iodines is monitored. Reference investigation and intervention levels are introduced for monitored indicators. Investigation and intervention levels are derived from annual reference levels of discharges for soon warning from growing trend of discharges. By this is ensured time for identification of causes and to do corrective measures. When intervention reference levels are exceeded, leakages shall be decreased bellow annual reference levels even if unit will be shut down. Results of monitoring, signalization of reference level excees including, are presented in radiation monitoring control room and operatively controlled by shift master of radiation control.

Annual referencelevels and measures during exceeding of reference levels are more detailed described in chapter 13.1.1. Monitored values, indicators and technical means for monitoring are presented in Monitoring plan [I.54] and in chapter 11.04 [I.55] of this POSAR.

Continual and balance monitoring af liquid discharges

Unexpected leakages prevention of radioactive substances in form of liquid discharges is ensured by radiation monitoring system prior to and during the discharge.

Radioactive water is accumulated in a control tank after its purification. Water in tank is sampled before its releasing. Radionuclide composition of the samples is determined by gammaspectrometry and radiochemical analysis, which is then compared to relevant derived limits (40 Bq/l for total volumic gamma activity). If the limits are exceeded, the purification is repeated. The discharge rate and dilution is determined based on measured concentration of radioactive substances and data of flow rate in waste canal and in river Hron in such a way that concentration of tritium at the discharge point is below the maximum allowed level (1000 Bq/l).

Continuous and balance monitoring is provided by radiation control system at the waste water station (SKOV), which is mutual for EMO12 and MO34. Current data about the volumic activity [Bq/l], discharged activity [Bq/h], canal flow rate [l/h] including alarm and exceeding of release levels are presented in radiation monitoring control room and are continually controlled by shift master of radiation control.

In case of radiation monitoring failure or exceeding of intervention level, the signal for the closure of a vent on discharge pipe is automatically generated and the discharge is stopped. The discharge can be started again only manually by shift master of radiation control. Before the discharge is started again all reasons of exceeding the intervention level must be investigated and eliminated. For this reason is performed laboratory control of special sample which is taken by automatic sampling device on the basis of intervention level exceeding. After the confirmation that the cause of exceeding of the intervention level was natural process (e.g. radon from sudden rain) the discharge continues. Annual reference levels for liquid discharges are presented in chapter 13.1.1 of this PpBS. Regime and technical means of monitoring are described in detail in [I.54] and in chapter 11.04 of this POSAR [I.55].

Monitoring technology processes

Radiation monitoring of technological proceses, devices and agents ensures the monitoring of radioactive substances movement in NPP technological systems and levels of their leakages, by which is ensured monitoring of barrier tightness. One of these systems monitors also leakages of ejector gases from water of II.O. directly into the atmosphere. Monitored radiation characteristics, methods and technical means of monitoring are detailed described in [I.54] and chapter 11.04 [I.55] of this POSAR.

Outputs from all measurement channels of monitoring technological proceses are presented at radiation monitoring control room. For all monitored quantities is ensured signalization of reference investigation and intervention level, which provides possibility to detect untightness and leakages already during teir origin and identification of respective device or system where is necessary to perform corrective actions. NPP operation with constantly low content of radioactive subsatances in technological agents and tightness of bariers are essential prerequisite to keep gaseous and liquid discharges below annual reference levels.

13.1.8 Methods on regular creation and archivation of records about radioactive leakages from NPP

Daily balance releases are determined on the basis of operative monitoring. They are comparing with limit levels according to respective releases permission of PHA SR. Daily records on the release measurement data are writen by Shift master of radiation protection into the "Daily report about radiation situation", and respective books [I.58] and [I.59].

Apart from that, the samples taken for balancing measurements of gaseous and liquid releases are regularly evaluated in laboratory. Recording of samples, their processing, measurement and evaluation is common for EMO12 and MO34 and is resolved in [I.57].

Samples of the individual components of the effluents are cumulated on appropriate filtering materials in the optimal frequency. The taken samples are measured in the laboratory with high sensitivity.

The sampling is iso-kinetic one with air flow-rate of 40 ÷ 120 m^3/hour (air blower of samplers are controlled by measurement system of air flow rate in primary sampling system). The samplers are equipped with flow-rate measurement and measurement of the total air volume.

Balanncing of gaseous efluents is based on discontinual measurements. Large area particulates filters are measured and evaluated weakly by laboratory gamma spectrometry. The filters for quarter of the year are analysed by radiochemistry. Large volume iodine cartridges are evaluated weakly by spectrometry.

Tricium traped in silicagel is evaluated monthly. Radiocarbone ^{14}C is evaluated twice weakly in LRKO Levice. The samples of radioactive noble gases taken into the pressure vessels are evaluated twice weakly by spectrometry.

On this basis the balance data is recalculated into discharded activities of.radioactive noble gases in given sampling period. Measurement of samples and creation of records is detailly documented in guide [I.62].

Exception is the volume activity of radioactive noble gases is monitored on the basis of the beta activity of the radioactive noble gases – mainly ^{85}Kr, ^{133}Xe, ^{41}Ar. The output quantity is the volume activity of radioactive noble gases (Bq/m3) and the effluent rate of radioactive noble gases (Bq/hour). In the case of continuouse measurements, data on measurements and exceeding of reference levels are signalised directly to the control room of radiation control and archived by the information system of radiation control on storage medium.

In the case of liquid releases the basic method of the monitoring is the discontinuous measurement. This method is provided by the sample taking and the evaluation of the sample in the laboratory (gross beta activity, gamma spectroscopy and Tritium analyses). Beside of operative measurement poured monthly samples are prepared from released water, as well. They serve for gammaspectrometry determination of volumic activity of the activation and fission products in the joint sample. In turn, joint half year samples are prepared in which activity of strontium and transuranic radionuclides are determined by radiochemical methods.

Determination of total activity of liquid discharges for given time period is calculated on the basis of RN volumic activities and volumes of discharged control tanks. Measurement procedures and creation of records for liquid efluents are described in more detail in [I.63].

Each sample includes cover letter. Data about the sample and measurement results are writing into books [I.60] and [I.61] and electronically into appropriate database. Balance evaluation of releases on the basis of sampling and flow rate measurement of air throught the ventilation stack and water throught waste channel is a part of quarter and annual reports submitted to PHA SR.

During measurement process is recorded all measurements results including values below MDA. Final balances discharges are determined on the basis of balance laboratory measurements of taken samples. Into balance of released radioactivity are included the measured average RN concentrations for given sampling period and in the cases of MDA their half values.

List of particular activation and fission products was agreed by PHA SR and it is the subject of releases permission.

Results of investigation of investigation level exceeding for gaseous and liquid releases are introduced in respective Summary reports on releases of radioactive matters from Mochovce NPP and their radiological impact on the environment [I.12].

At exceeding of action reference levels for gaseous or liquid releases the employee is obliged to announce this reality to his leader, group leader, shift master of operation radiation control and manager of radiation protection unit. Shift master of operation radiation control (ZMRKP) informs the shift engineer and follows at evaluation of event consequeces acoording to the guide [I.56]. If it is clear on the basis of radiation situation data that leakages of radiaoctive matter happened or can happen then in accordance with the on-site emergency plan [I.52] he must determine his size, pathway of leakages and sorce term.

13.1.9 Measures for accessing of respective data on leakages to responsible authorities and public

Evaluation of liquid and gaseous radioactive discharges, comparing them with the authorized limits and assessing their impact on the environment expressed by individual effective dose of population in the NPP vicinity is presented in the quarterly and annual "Summary report on radioactive discharges from the NPP Mochovce and their radiological impacts on the environment" [I.12].

The content of above mentioned reports details the chapter 13.1.5. These reports are submitted to authorities - NRA SR and PHA SR.

Public is informed of respective measured data by reports presented in regular monthly intervals or by annual reports at web page of SE (www.seas.sk). Authorities are in more detail informed by quarterly and annual reports, which the keeper is obliged to prepare and send to the Authorities according to the relevant Decision [I.3]. According to item 27 of the decision the keeper is obliged to submit following reports:

a) Notification on exceeding of radiological limit; immediately, latest next working day after detection,

b) Notification on exceeding of annual refrence levels; immediately, latest next working day after detection,

c) Notification on exceeding of investigation and intervention levels; immediately, latest up to 5 working days after detection,

d) Notification on malfunction of each monitoring system for continual or balance monitoring of activity or system for measurement of amount of efflueants; immediately, latest next working day after detection,

e) Report on results of causes investigation and consequences of limit exceeding, annual reference level , investigation or intervention level; up to 20 working days after detection,

f) Report on activity of effluents and wastewaters, including preliminary evaluation of its influence of dose burden to the population, for each calendar quartal; up to 60 days after end of quartal,

g) Report on yearly balance of radioactive matters released into the atmosphere and surface waters, including its evaluation on dose burden to the population; up to March 31st of following year.

Managers of radiation protection units and nuclear safety units and specialists of radiation protection prepare materials into National report of SR, elaborated according to the Convention on nuclear safety ratified by Slovak Republic.

In addition, the notifications about exceeding of the limits and reference individual doses, exceeded investigation and intervention levels for gaseous and liquid discharges, loss of function devices for the monitoring of discharges and so on are sent to the authorities according to operation license [I.3].

During normal operation is in accordance with [I.64] in cooperation with local and state administration provided the regular informing of the public on those activities and documents related to the protection of the population in the endangered area.

Informing of the public is generally focused on information about the effects of ionizing radiation on human health and environmental impact of possible events on JZ and the possible consequences on the population, on the principles of protection plans, warning and basic activities during individual events. Spreading of information is ensured through corporate and local newspapers, posters, calendars, brochures, information center activities, media, lectures in municipalities, schools and organizations involved in emergency preparedness, organizing of emergency exercises.

In case of an incident connected with the leakage of RAL, the shift engineer or the head of the emergency committee shall promptly give a call NRA SR about an event.

NRA SR has Emergency Response Centre, which in case of emergency informs European Commission, International Atomic Energy Agency and surrounding states. The representative of NRA SR participates on the work of emergency committee as supervision in its decisions, which are subject to approval of the head of emergency committee and on the work of the monitoring group as a supervision in development of recommendations to protect the public.

13.2 Non radiological impacts

13.2.1 System of environmental management as the tool for permanent improvement of the relation of EMO to living environment

The care of the living environment is in EMO resolved complexly in all areas by the application of controlling tool named Environmental Management System (EMS). The controlling of the impact of the power plant to individual components of living environment is the non-separable part of the EMS. System EMS follows and evaluates the produced non-radioactive solid and liquid waste, wastewater from the system of wastewater cleaning, from the input water chemical treatment and the non-radioactive effluents into atmosphere. The system follows the volumes of the consumed drinking water and surface water for technological reasons.

The EMS system in Mochovce NPP was established for the reason to demonstrate the effort for permanent improvement of all activities in the relation to living environment and to guide and control such activities to permanent sinking of the influence to the living environment. The environmental policy of EMO is applied by the means of the Long-term and short-term environmental targets (DaKEC) and other elements of the EMS system, which follow and precise the environmental policy of SE, a.s to the actual requirements of the protection of living environment.

13.2.2 Description of the inputs

13.2.2.1 Water management

13.2.2.1.1 *Consumption of the surface water*

The surface water for the support of EMO operation (technological water) is taken from the Hron River, from the water reservoir Veľké Kozmálovce. The annual limit, in accordance with the valid licence issued for four reactor units of NPP Mochovce by the water-management authority, which reads of 47 304 000 m^3/year. The license for consumption of the surface water was issued by the District authority in Banská Bystrica as the decision No 1094/2/177/405.1/93-M from 6.7.1993 [I.35].

The consumption of the surface water for industrial reasons is conditioned by the plant operation and, it depends from the quantity of produced electricity. The development of the consumption in the period 2001 – 2010 is assigned in Tab. 13-28.

The quality of the taken surface water depends closely with sedimentation in the water reservoir Veľké Kozmálovce, which serves for the delivery of technology water for EMO. The deterioration of the quality of taken technology water from water reservoir has the impact of the lower density in the cooling circuits and thereby the increasing of the water consumption per MWh produced. Based on the estimation, the volume of sediments creates about 50% of the retention volume of the reservoir.

The consumption of the surface water during the operation of MO34 will be similar as those in EMO12 (about 21 000 000 m^3 per year). The consumption of the EMO complex will be doubled against the contemporary consumption.

Tab. 13-28 Trends of quantity of the intake and consumption of surface water in the dependence from the production of electricity

Year	Volume of taken water in m^3	Electricity production MWh	Water consumption m^3/MWh
2001	16 788 751	5 391 342	3,11
2002	18 218 200	5 870 235	3,10
2003	19 286 611	6 238 525	3,09
2004	17 615 583	5 482 865	3,21
2005	19 313 417	6 239 944	3,09
2006	18 949 001	6 320 254	2,99
2007	19 994 286	6 828 737	2,93
2008	20 626 000	6 890 967	2,99
2009	20 759 000	7 010 189	2,96
2010	21 012 188	7 147 266	2,94

It is possible suppose that the surface water consumption during the construction and following operation of MO34 will not over-range the established limit of 47 304 000 m^3 per year. Verification calculations of water consumption are performed in [I.40]. The solution of the problem of the sedimentation in the water reservoir Veľké Kozmálovce is in the competence of the water stream administrator.

13.2.2.1.2 *Consumption of the underground water*

Grounwater is pumped from two artesian wells in the village Červený Hrádok owned by SE, about 8 km from EMO. The maximum allowable flow rate is 18 l/s , resp. 15 l/s. Groundwater is the treatment used for drinking.

Undeground water was till the year 2005 taken for EMO mainly from the source in the property of EMO consisting from two artesian wells in the village of Červený Hrádok, as well as from the standby water source managed by company ZsVaK in Kalna nad Hronom. Since 2006 the demand for drinking water is satisfactorily covered by delivery from Červeny Hradok wells (the water source from Gabčíkovo is assigned as a reserve one).

Water distribution is executed by a pumping station above the drills, by water treatment, incoming pipelines and by the 2 x 400 m^3 water reservoirs of the power plant.

Drinking water from public duct of waterworks and sewages of western Slovakia connected in Cerveny Hradok village is supplied as well to the water reservoir.

The drinking water main at the power plant area is connected to these water reservoirs.

According to [I.27], total consumption of drinking water during the operation of MO34 will be cca 249 660 $m^3.year^{-1}$.

Currently the well in the Červený Hrádok provide sufficient drinking water for EMO.

Tab. 13-29 Trends of the underground water consumption in EMO in period 2001-2010.

Year	Consumption of drinking water from ZsVaK Kalna [m^3]	Consumption of the underground water from Červený Hrádok source [m^3]	Total
2001	48 723	311 393	360 116
2002	32 677	303 950	336 627
2003	39 601	311 020	350 621
2004	47 167	353 940	401 107
2005	22 305	178 760	201 065
2006	-	144 828	144 828
2007		83 478	83 478
2008		91 378	91 378
2009		83 825	83 825
2010		110 915	110 915

Trend of the volume of taken underground water has the decreasing character from the year 2005 to 2007 – see Tab. 13-29. The water-meter systems helped to identification of leakages in the distribution network; the leakages were repaired or distribution network exchanged. In 2008 the volume of the taken groundwater was soft increased, but it was not needed to take any measures beyond the normal activities. The decreasing was recorded in the 2009 and increasing again in the 2010.

13.2.2.2 Raw materials

The consumption of the raw materials during the operation of MO34 will be similar as those in EMO12.

The basic element for the heat production in MO34 NPP will be the fuel assemblies containing the fuel elements (rods) with slightly enriched UO_2. Approximately one quarter of the fuel assemblies is to be exchanged once a year. Besides the fuel assemblies also emergency, control and compensation elements are to be installed in the nuclear reactor. The consumption of the nuclear fuel in MO34 will represent about 12,5 ton of material in a year.

Other consumable elements and materials are active carbone and filters for the capture of radioactive particulates and isotopes of Iodine; ion exchange resins for radioactive water cleaning; hydrogen and nitrogen; boric acid; other chemical agents; decontamination solutions; engine fuels; lubrication oils and lubricants; transformer oils etc.

An important raw material is DEMI water, which serves as replacement of the water losses in related circuits and for some other purposes.

The materials for operation and maintenance of the machinery and other technology equipments (sealing materials; lubricants; protection paintings; cleaning means etc.), the materials for operation and maintenance of the civil structures and their exteriers will be necessary for NPP MO34 in Mochovce. The consumption of these miscellaneous materials varies in the range from few tens of kg until some hundreds of tons (e.g. materials needed for maintenance and reconstruction of civil structures etc.). According the qualified estimation the total materials consumption will be in the range of 20 to 25 thousand tons a year.

Among the other raw materials, connected with operation and maintenance of NPP equipments, it is necessary to involve such substances, which are neutral against the living environment, which are consumed in the technology and maintenance (protection paintings, colour paintings), or such materials after utilisation create waste of the category "O" (paper, wood, etc.). Various chemical agents and oil products (i.e. substances hazardous for water or the living environment) create the second group. The consumption of the chemical agents in EMO during 2010 is assigned in the Tab. 13-30.

The consumption of material assigned in the table will be doubled in EMO after the start-up of MO34. The nuclear fuel assemblies are delivered from the Russian federation. Remaining consumable materials for EMO12 NPP are procured according the needs, availability and prices from inland or abroad suppliers.

Tab. 13-30 Consumption of chemical agents in EMO in 2010

Name of agent	Consumption Tons/year	Name of agent	Consumption Tons/year
Sulphuric acid H_2SO_4	260,902	Biocíd DILURIT GM ACT Giulini	16,29
Sodium hydroxide NaOH	334,660	Biocíd DILURIT GM CAT Giulini	28,41
Hydrazine hydrate N_2H_4	16,689	POF KOARET Giulini	10,775
Ferrous sulphate $Fe_2(SO_4)_3$	2 103,926	BIOCID NALCO STABREX ST70 pre TVD	5,611
Calcium hydrate $Ca(OH)_2$	2 015	Inhibitor of corrosion (NALCO 7359.61R pre TVD)	4,046
AmmoniaNH_4OH	65,311	Stabilizer of hardness (NALCO TRASAR 3DT195)	2,079
Potassium hydroxide KOH	0,2	H_2 in Nm^3	10,983
Nitric acid HNO_3	9,898	BIOCID GIULINI DILURIT 808	1,2
Sodium phosphate Na_3PO_4	0,210	Topecor	0,3
Sodium sulphate Na_2SO_3	1,025	N_2 in m^3	471,992
Boric acid H_3BO_3	1,85	Duozon(chlordioxid) for drinking water	0,875
Organic coagulant (POK MIKROSORBAN KOAGULANT Giulini)	6,7	Turbine a transformer oils in m^3	0
Stabilizer of hardness (TURBODISPIN Giulini)	0,2	Silicium filtration sand 0,6-1,2 mm	8,2
Stabilizer of hardness (AKTIPHOS Stabilizátor Giulini)	29,801	O_2 v m^3	19,064

Note: Some chemicals with smaller consumption (ion exchange resins, petroleum for dieselgenerator station, turbine oil,...) are not procured every year, hence they are not listed in this table.

13.2.2.3 Sources of energy

Power and energy in EMO are acquired from the own source except the natural gas delivered from Slovak Gas Industry SPP.

The EMO belongs to the biggest facilities for production of electrical power in the Slovak republic. The electrical power is the main consumed power in NPP. NPP covers the consumption from the own production. Own consumption of electrical power during the operation of MO34 will be similar one like in EMO12. Such own consumption creates about 1,07% from totally produced electrical power (about 483 000 MWh per year. It may be supposed that the own consumption of EMO will be doubled (966 000 MWh per year) after the MO34 NPP start-up.

The heat for EMO is exhausted from the surplus of the thermal energy produced in the nuclear reactors of the power plant. The heat consumption of EMO12 operation was 2 231 TJ (terra joule) in 2006.

According the data provided by EMO12 operator [I.28], the quantity of heat removed through one cooling tower into atmosphere is 440 GCal/h = 1839,2 GJ/h, i.e. 7356,8 GJ/h from four cooling towers. Yearly it is about 64 445,6 TJ. Plant internal heat consumption with respect removed heat is 3,46%.

The complementary sources for the heat production is the support start-up boiler (with annual consumption of 5 236 m^3 of natural gas in 2010). In 2009 another of air pollution was added - gas boiler at LRKO (consumption of gas in 2010 14 038 m^3).

The heat necessary for heating, for the preparation of the warm service water and for the technology installation reasons may be consumed from the above-mentioned heat sources of EMO. With respect to the original extent of the four-reactor units EMO NPP, it is possible suppose that the capacity of the mentioned heat sources will be sufficient.

The consumption of the heat during the operation of MO34 NPP will be similar to the EMO12 heat consumption – i.e. about 2 230 TJ. The production of the waste heat removed through eighth cooling towers into the atmosphere compared with waste heat from EMO12 will be doubled to about 130 000 TJ.

The consumption of natural gas and engine fuels will be provided with local distribution networks during the operation. It is supposed only slight increase of the consumption.

13.2.2.4 Transport and other infrastructure

The network of road communications and railway sidings was built in the past. For the needs of EMO, road connections, railway connection and connections of distribution systems and telecommunication systems interconnections were already realised. The networks of road site-communications, railway sidings and distribution networks ware designed and built for the needs of all four reactor units of NPP. The loading of the road and railway communications and needs to the technical structure of the site will be not changed significantly during the MO34 operation.

13.2.3 Description of the outputs

13.2.3.1 Volume and composition of the wastewaters

Wastewaters at input and output of water cleaning station are analysed in accordance with internal documents [I.41], [I.42] by EMO laboratory. Results of the analysis are presented below.

According to the [I.27], the total volume of released waste water to the Hron river will be cca 6 914 373 m^3/year (except of rainfall waters). The industrial waters will be on level of 6 664 713 m^3/year and sewage waters 249 660 m^3/year.

The volume of released waters did not exceed the licensed annual values established in the decision of Regional authority in Nitra No2007/00029 from 25.1.2007 [I.36] valid for 2 or 4 reactor units respectively according to the number of reactor units operated. See Tab. 13-31.

Total volume of the released water to the Telinsky potok creek from the sludge basin Čifáre (CS 611/9-01) serving to the storage of sludge from water treatment (coagulation) was 306 463 m^3 in 2010. The limit value was assigned in the decision of Regional authority in Nitra No 2004/00408, from 22.7. 2004 is 252 288 m^3. Overrun of given limit was caused by extreme amount of rainfalls in 2010, which was reported to Regional authority in Nitra and to SPV Piešťany.

Tab. 13-31 Trend of the released waste-water volume in the period 2000 - 2010

Year	Total volume of released waste waters [m^3]	Volume of released industrial waste waters [m^3]	Volume of the cleaned sewage waters [m^3]	Annual limits of released waters for
2000	5 392 456	4 788 513	603 943	12 097 000
2001	3 868 857	3 571 575	297 282	12 097 000
2002	4 727 521	4 427 582	299 939	12 097 000
2003	4 746 385	4 417 581	328 804	12 097 000
2004	4 648 856	4 285 390	363 466	6 000 000
2005	5 126 804	4 969 195	157 609	6 000 000
2006	4 858 647	4 762 647	96 000	6 000 000
2007	4 450 000	4 367 000	83 000	6 000 000
2008	4 812 820	4 721 442	91 378	6 000 000
2009	4 818 835	4 735 010	83 825	6 000 000
2010	5 426 855	5 315 940	110 915	6 000 000

Note: Limits of wastewaters for years 2000, 2001, 2002 and 2003 are established for 4 reactor units.
Limits for years 2004 - 2010 are established for 2 reactor units.

The volume of released water from drinking water treatment station in Červený Hrádok into the Širočina creek was 1 625 m^3 in 2010. The limit value was assigned in the decision of Regional authority in Nitra č. 2003/015777, from 29.10. 2003 [I.37] in word of decision No 2007/00029 from 29.10.2003 [I.38], by which extended lawfulness up to 31.12.2014, is 10 000 m^3.

13.2.3.1.1 *Evaluation of the quality of released waters*

Analysis of water at the input and output are performed according to internal documentation by EMO laboratory. Results of the analysis are visible below.

New values of the indicators of wastewaters released into the Hron River were established in the decision of the water management office of the Regional authority in Nitra, department of the environment No 2007/00029 from 25.1.2007 [I.39]. The validity of decision was prolonged in 2010 until 2013.

The concentration and balance of the produced contamination limits assigned in the Tab. 13-32.

The development of the concentration values of the chemistry indicators values in the wastewater released into the Hron River recipient in the period of 2005 to 2010 are assigned in in Tab. 13-33 and balance values in Tab. 13-34. Balace data presented in Tab. 13-32 are yearly averages of 24 hours compound samples.

Tab. 13-32 **Comparison of both quantitative and qualitative indicators of wastewater contamination released to the Hron River stream with limits in 2006**

Indicator	Allowed limit concentration [mg/l] except pH and T	Average concentration [mg/l]	Allowed balance values [t/year]	Reached balance values of contamination released to the Hron [t/year]	Sampled contamination from Hron river [mg/l]	Sampled contamination from Hron river [t/year]
$CHSK_{Cr}$	35	16,88	210	91,61	12,17	255,718
$N\text{-}NH_4$	1,5*	0,2934	9	1,59	0,13	2,732
Cl_-	100	29,33	600	159,170	5,80	121,871
BSK_5	12	1,8	90	9,768	2,27	47,698
NEL	0,5	<0,1	3	<0,543	<0,1	<2,1012
RL_{105}	1500	829,54	9000	4501,793	175,67	3691,211
RL_{550}	1000	645,35	6000	3502,221	86,17	1810,620
$P_{celk.}$	1,00	0,361	6	1,959	0,17	3,572
T [^{0}C]	30	18,182	-	-	–	-
NL	40	<12,342	240	<66,978	20,17	423,816
SO_4^{2-}	690	270,382	4140	1467,324	28,67	602,419
pH	6,0-9,0	8,769	-	-	7,91	-
Hydrazín	0,5	<0,0225	3	<0,122	<0,02	0,420
Active Cl	0,1	<0,0525	0,6	<0,285	<0,05	1,051
AOX	0,2	<0,05	1,2	<0,271	<0,05	1,051
$N\text{-}NO_3\text{-}$	16**	7,9762	96	43,286	1,13	23,744

* in time of waste water release from neutralization tanks 3,0 mg/l.

** possibility to overrun 5 times a year up to 22 mg/l. Analysis of parameters according to valid decision are performed 48x per year except of BSK_5, hydrazine - 12x per year and AOX, NEL, active chlorine 4x per year.

Collected pollution form the river Hron is analysed in the raw water 6 times a year and presented balance values are calculated in the total volume of the water collected from the river Hron.

Vocabulary:

$CHSK_{Cr}$ - Chemical consumption of Oxygen

BSK_5 - Biological consumption of Oxygen

NEL - Non-polar extractable substances

RL_{105} - Dry remainder after 105°C evaporation

RL_{550} - Dry remainder after 550°C evaporation

$P_{celk.}$ - Total Phosphor

NL - Non-soluble substances

AOX Adsorb-able organic bonded Halogens

Tab. 13-33 Development of the concentration values of the chemistry indicators in wastewater released to the recipient the Hron River in [mg/l] in the period 2005–2010

Indicator	Reached contamination in the released wastewater [mg/l]						
	Limit	2005	2006	2007	2008	2009	2010
$CHSK_{Cr}$	35	14,32	16,275	15,38	14,47	<15,214	16,88
$N\text{-}NH_4$	1,5*	0,26	0,414	0,38	0,42	0,395	0,2934
Cl^-	100	37	43,31	42,22	39,40	45,38	29,33
BSK_5	12	5,02	2,7	2,0	2,00	2,3	1,8
NEL	0,5	0,1	0,1	<0,1	<0,1	<0,1	<0,1
RL_{105}	1500	857	992,65	1115,44	965,31	970,74	829,54
RL_{550}	1000	638	710,775	895	768,67	762,98	645,35
T [^{0}C]	30	11,8	15,33	18,12	18,70	18,97	18,182
$P_{celk.}$	1,00	0,34	0,358	0,39	0,39	0,348	0,361
NL	40	13	11,46	11,56	13,80	<10,122	<12,342
SO_4^{2-}	690	357,9	424,47	416,96	323,75	339,37	270,382
$N\text{-}NO_3^-$	16**	8,74	8,834	11,04	10,51	11,72	7,9762
Hydrazine	0,5	0,17	<0,2	0,04	<0,2	<0,02	<0,0225
Active Chlorine	0,1	0,05	0,053	<0,05	0,05375	0,06	<0,0525
AOX	0,2	0,207	<0,2	<0,11	<0,1	<0,07	<0,05
pH	6,0-9,0	8,68	8,715	8,75	8,80	8,77	8,769

Tab. 13-34 Development of the balance values of chemistry indicators in the wastewater released into the recipient the Hron River in [t/year] in the period 2005 – 2010

Indicator	Reached contamination in the released wastewater [t/year]						
	Limit	2005	2006	2007	2008	2009	2010
$CHSK_{Cr}$	210	75,67	79,05	68,44	69,64	<73,31	91,61
$N\text{-}NH_4$	9	1,33	2,01	1,69	2,021	1,9	1,59
CL^-	600	189,66	210,4	187,88	189,625	214,875	159,170
BSK_5	90	25,7	13,1	8,9	9,625	10,891	9,768
NEL	3	0,51	0,485	<0,445	<0,481	<0,474	<0,543
RL_{105}	9000	4736,4	4 822,29	4963,708	4645,863	4596,464	4501,793
RL_{550}	6000	3618,9	3452,94	3982,75	3699,470	3676,7	3502,221
$P_{celk.}$	6	1,74	1,74	1,735	1,877	1,68	1,959
NL	240	65,8	55,67	51,442	66,417	<48,78	<66,978
SO_4^{2-}	4140	1834,54	2061,37	1855,472	1558,15	1606,92	1467,324
Hydrazine	1,2	0,87	<0,97	<0,4895	<0,481	<0,337	<0,271
Active Chlorine	96	0,25	42,91	49,128	50,582	55,494	43,286
AOX	210	1,02	79,05	68,44	69,64	<73,31	91,61
$N\text{-}NO_3^-$	9	44,8	2,01	1,69	2,021	1,9	1,59

13.2.3.1.2 *Evaluation of the efficiency of the cleaning of sewage waters*

The following concentration values of the followed indicators were reached according [I.28] in the year 2010. The analyses of samples from both inflow and outflow of wastewater cleaning station are provided with the frequency of 4 times a year. The efficiency of the cleaning is in accordance with designed values for given type of the wastewater cleaning station see Tab. 13-35.

Tab. 13-35 Balance of the efficiency of the sewage waters cleaning station in 2010

Indicator [mg/l]	Inflow value [mg/l]	Outflow value [mg/l]	Cleaning efficiency [%]
$CHSK_{Cr}$	269,48	25	90,72
NH_3	29,17	15,89	45,57
PO_4^{3-}	10,66	3,03	71,62
BSK_5	139	3	97,84

13.2.3.1.3 *The quality of released wastewaters from the sludge basin Čifáre*

The quality of released wastewaters from the sludge basin Čifáre (CS 611/9-01) into Telinský creek reached the values listed in Tab. 13-36. The analyses frequency is 6 times a year.

Tab. 13-36 Comparison of both qualitative and quantitative indicators of contamination released into the Telinský potok Creek from sludge basin Čifáre in years 2006 - 2010

Indicator	Allowed limit concentrati on [mg/l]	Average concentration [mg/l]				
		Year 2006	Year 2007	Year 2008	Year 2009	Year 2010
$N\text{-}NH_4$	0,5	0,11	<0,1	<0,1	<0,135	<0,143
RL	2000	307,83	313,3	284,3	247,3	299,33
NL	20	<10	<10	<10,3	<10	<10
pH	6,0-8,7	7,96	8,06	8,23	8,1	8,12
	Allowed balance values [t/year]	**Reached balance values [t/year]**				
$N\text{-}NH_4$	0,126	0,025	<0,0123	<0,0141	<0,022	0,0438
RL	504,6	70,16	38,75	40,086	40,45	91,733
NL	5,0	<2,28	<1,24	<1,452	<1,636	<3,06

The analyses were provided from 8-hours mixed samples 6 times a year according the Decision.

The obligation of an accreditation of the laboratory providing sampling and analyses of the waste water inured from 1.1.2007. The process of the accreditation of the EMO chemistry laboratory was successful finalised in December 2006. On the basis of the decision of the company, the EMO accredited laboratory provides the sampling and analyses of samples for the monitoring of allowed contamination values of watewater pollution prescribed by the water authority for EMO.

13.2.3.1.4 *Wastewater during MO34 operation*

During operation of MO34 it is assumed comparable amount of waste water as from EMO12 and therefore the total volume of waste waters for EMO will be probably two times higher.

13.2.3.2 The protection of the atmosphere

Operation of the atmospheric pollution sources

The following sources of the atmospheric pollutions were operated by EMO in 2010. Beside the consumed fuel, the values of the pollutions are assigned in Tab. 13-37. The fuel used was the natural gas except diesel-generators powered by diesel-oil.

The EMO start-up boiler belongs regarding its power to “large pollution sources. On the basis of the decision of the district authority in Levice Nr T-2003/00451-OVZ-KE from 19.3.2003, the obligation of accredited pollution measurement arises in the case; this boiler is in operation more than 360 hours in year. Regarding the fact, this boiler doesn’t reach such value in 2010; the accredited pollution measurement was not obliged. The EMO obtained the integrated operational license in the decision of Slovak Inspectorate of the Living Environment, Inspectorate of the Living Environment, Department of the Inspection of Nature and Country No 4273/985-OIPK/05-Kk/370700105 from 29.7.2005.

Tab. 13-37 Volume of the consumed fuel and the emissions from atmospheric pollution sources of EMO in 2010

Source	Consumed fuel volume, [m^3]	TZL [Tons]	SO_2 [Tons]	NO_x [Tons]	CO [Tons]	TOC [Tons]
middle and big sources of pollution						
Support start-up NG driven boiler EMO	5 282	0,0004	0,00005	0,0088	0,0029	0,00037
Diesel-generator stations– diesel oil [Tons]	80,6	0,131	0,001848	0,462	0,07392	0,010534
Total EMO:	-	0,1 31	0,1 896	0,4 7058	0,0 76856	0,0 10907
small sources of pollution						
Source			Amount of issued, consumed fuel or cleaned waste water			
DGS LRKO - small source - diesel oil in tons			0,005			
Gas boiler LRKO - small source - natural gas in m^3			14 038			
Waste water cleaner EMO - cleaned waste waters in m^3			110 915			
Issuing office of propellants, amount of issued fuel in m^3			41			

On the basis of submitted data on pollution from individual sources EMO, the appropriate fees for atmosphere pollution were calculated and paid in individual years.

The EMO fulfilled the notification obligation due the notification of the data on emissions from large source (Support start-up boiler), the medium sources (diesel aggregates on the site) to the Regional authority of living environment in Levice, whereupon this authority issued the decision No.: T-2011/00128-OVZ-KE of 17.3.2011 about the level of charges for air pollution in 2010 in the amount of € 167.

13.2.3.3 Waste management

13.2.3.3.1 *Waste treatment*

Total waste production increased in 2010 compared to the years 2006-2009 is associated with increased production of sludge by about 500 t (related to the increase of the production elec.energy and surface water taking). Production of hazardous wastes does not exceed the normal annual production in EMO.

The wastes from production of EMO are treated in accordance with legal rules valid for the waste management as well as with internal procedures (PO/5100 a EMO/SM 013.05, which includes “Program of waste management” and others) and the decisions of Regional environmental authority Levice No.T-2007/00516-ODP-Z from 29.03.2010 on treatment of hazardous waste which substituted decision T-2010/00563-ODP-Z.

The authority approved the Program of waste management for the period until 2005 in decision No T-2003/00198-ODP-Oá from 19.2. 2003. Final statement for strategic document “Program of Waste Treatment of Nitra’s district for the eyars 2011 - 2015” has been issued on 6.6.2013.

The authority awarded the approval for treatment or commission of recyclable waste by decision No.T-2004/00966-ODP-K from 11.8. 2004

Of the total quantity of 5192,5264 tons of waste in 2010 was produced 3937 t of sludge form the treatment of raw water stored in the pond, which is included in the total amount of waste category “0”.

The generation of non-radioactive waste in EMO corresponds to the concentration of the work activity, which hasn’t character of the commodity manufacturing but the character of maintenance and supporting works. For such reason, the place of the waste collection is defined as the place of waste generation. A comparison of the proportion of recovery and disposal of waste in the perion 2007 to 2010 is shown in the Tab. 13-38.

Tab. 13-38 Quantities of produced waste in the period of 2007-2010

YEAR	2007	2008	2009	2010
Total amount of produced wastes [Tons]	4050,3	4695,2	4 546,6	5 192,5
Amount of recycled wastes [Tons]	211,8	347,6	398,9	597,0
Evaluation [%]	5,2	7,4	8,8	11,5
Amount of disposed wastes [Tons]	3 838,5	4347,7	4147,7	4595,5
Evaluation [%]	94,8	92,6	91,2	88,5

The overview of the production, assortment and categories of waste and method of their disposal according the notification of EMO in the year 2010 is assigned in the attached table – Tab. 13-39.

Tab. 13-39 Production of waste according the catalogue and waste categories in EMO in 2006

Order No	Waste code	Waste name according the Catalogue of waste	Waste category	Y-Code	Quantity (t/year)	Method of waste treatment	
						Code	Company, place
1	030105	sawdust, shavings, cuttings, wood, particle board and veneer	O		11,61	D1	Márius Pedersen, a.s. Trenčín- Tekovská ekologická
2.	070104	other organic solvents, washing liquids and mother liquors	N	42	1,33	R12	Márius Pedersen, a.s. Trenčín- Tekovská ekologická
3.	080111	waste paint and varnish containing organic solvents or other dangerous substances	N	12	2,94	D1	Márius Pedersen, a.s. Trenčín- Tekovská ekologická
4.	080317	waste printing toner containing dangerous substances	N	12	0,365	D1	Márius Pedersen, a.s. Trenčín- Tekovská ekologická
5.	080318	waste printing toner other than those mentioned in 08 03 17	O		1,702	R3	Telegrafia Košice
6.	101304	wastes from calcination and hydration of lime	O		60,13	R10	PD Kalná nad Hronom
7	101304	wastes from calcination and hydration of lime	O		1,785	DO	EMO-zamestnanci
8	120101	ferrous metal filings and turnings	O		10,42	R4	KOVOMAT Levice
9	130206	synthetic engine, gear and lubricating oils	N	8	6,76	R9	ECOREC Pezinok
10	140603	other solvents and solvent mixtures	N	42	1,93	R12	Márius Pedersen, a.s. Trenčín
11	150101	paper and cardboard packaging	O		26,14	R3	Zberné suroviny
12	150103	wooden packaging	O		4,74	D1	Márius Pedersen, a.s. Trenčín
13	150106	mixed packaging	O		83,4	D1	Márius Pedersen, a.s. Trenčín
14	150109	textile packaging	O		0,014	DO	
15	150110	packaging containing residues of or contaminated by dangerous substances	N	12	1,06	D1	Márius Pedersen, a.s. Trenčín
16.	150202	absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	N	22	6,363	D1	Márius Pedersen, a.s. Trenčín
17	160103	end-of-life tyres	O		1,1	R3	Márius Pedersen, a.s. Trenčín
18	160213	discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	N	31	0,48	R3	Metalservis Recycling Banská Bystrica
19	160213	discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	N	29	0,001	R4	Márius Pedersen, a.s. Trenčín
20	160213	discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	N	31	1,309	R4	Metalservis Recycling Banská Bystrica
21	160213	discarded equipment containing hazardous components (16) other than those mentioned in 16 02 09 to 16 02 12	N	29	0,471	R5	Metalservis Recycling Banská Bystrica
22	160214	discarded equipment other than those mentioned in 16 02 09 to 16 02 13	O		12,71	R4	Metalservis Recycling Banská Bystrica
23	160506	laboratory chemicals, consisting of or containing dangerous substances,	N	34	0,069	D9	Márius Pedersen, a.s. Trenčín

Order No	Waste code	Waste name according the Catalogue of waste	Waste category	Y-Code	Quantity (t/year)	Method of waste treatment	
						Code	Company, place
		including mixtures of laboratory chemicals					
24	160601	lead batteries	N	31	19,432	R4	MACH TRADE Sereď
25	160602	Ni-Cd batteries	N	26	0,11	R4	MACH TRADE Sereď
26	170401	copper, bronze, brass	0		275,02	R4	Demont Slovakia
27	170411	cables other than those mentioned in 17 04 10	O		1,04	R4	KOVOMAT Levice
28	170411	cables other than those mentioned in 17 04 10	O		0,04	DO	EMO -zamestnanci
29	170904	mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03	O		176,92	D1	Márius Pedersen, a.s. Trenčín- Tekovská ekologická
30	190805	sludges from treatment of urban waste water	O		96,26	D1	Márius Pedersen, a.s. Trenčín- Tekovská ekologická
31	190810	grease and oil mixture from oil/water separation other than those mentioned in 19 08 09	N	9	17,26	R1/ R12	Márius Pedersen, a.s. Trenčín- Tekovská ekologická
32	190902	sludges from water clarification	O		3937	D4	Odkalisko EMO Mochovce
33	190905	saturated or spent ion exchange resins	O		31,58	D1	Márius Pedersen, a.s. Trenčín- Tekovská ekologická
34	191001	iron and steel waste	O		86,576	R4	TSR slovakia
35	191001	iron and steel waste	O		2,2139	DO	Zamestnanci EMO
36	191001	iron and steel waste	O		49,52	R4	KOVOMAT Levice
37	191002	non-ferrous waste	O		0,521	O	KOVOMAT Levice
38	191002	non-ferrous waste	O		0,021	DO	Zamestnanci EMO
39	191204	plastic and rubber	O		3,62	R12/ R3	Márius Pedersen, a.s. Trenčín- Tekovská ekologická
40	191204	plastic and rubber	O		4,0955	DO	Zamestnanci EMO
41	191207	wood other than that mentioned in 19 12 06	O		1,049	O	Zamestnanci EMO
42	200108	biodegradable kitchen and canteen waste	O		10,2	R1	Kuchyňa EMO
43	200301	mixed municipal waste	O		5,82	D1	TS Tlmače
44	200301	mixed municipal waste	O		199,479	D1	Márius Pedersen, a.s. Trenčín- Tekovská ekologická
45	200304	septic tank sludge	O		37,92	D8	ČOV EMO Mochovce

Note: Waste categories:

O – Category “other”

N – Category “hazardous”

The sludge from the raw water coagulation will be preferably squeezed and dewatered sludge with dry content of 55% will be produced in total ammout of 21 482 $m^3.year^{-1}$. The sludge will be transported to the Čifáre sludge disposal or to an operating dumping site. The existing hydraulic transportation will be preserved as an alternate solution [I.30].

The sludge from sludge fields of the sewage water cleaning can be after satisfactory radiation control disposed off on public disposal having a permit for this type of waste. If the radiation control will be unsatisfactory, the sludge from the sludge fields must be stored on EMO site.

Disposal of other types of sludge - like e.g. sludge from retention reservoirs, will be guided on the basis of performed analyses according to parameters prescribed by legislation.

The sludge in cooling tower should be also followed, which is of interest for reason of lowering cooling if it should get into condensers below the turbines. At least once per 4 years the pools under cooling towers are cleaned. The sludge (about 40 to 50 t) is transported also to the sludge lagoon in Čifáre.

The sludge in reservoirs of raw water (2x6000m^3) is lowering the storage capacity of these reservoirs. On the basis of operational experience due to sludge sedimentation on the bottom the capacity of reservoir will decrease by approximately 2 % per year, i.e. by 240 m^3 in favour of sledges. At assumed density 1.5 to 2 t/m^3 this amount of sludge is about 360 to 480 tons, which makes about 0.25 % of about 190 000 t total sludge produced by EMO per year.

The sediments from the water dam Veľké Kozmálovce create the serious problem for the operator of this dam, i.e. SVP Banská Bystrica. The SVP resolves this problem. The cleaning of the water dam is a task of the water stream administrator and not the task of the operator of EMO.

13.2.4 Sources of noise and vibrations

13.2.4.1 Sources of excessive noise

During the identification of noise sources in the operational areas of EMO, the process of identification comes out from the decision of SR government on minimal health and safety requirements to protection of workers – ear protection. Five contained areas are declared in EMO regarding the noise:

- The pumping station of the essential service water
- Turbine hall
- De-carbonisation – hall “C”
- NT compressor hall
- Start-up support boiler

During the operation of MO34 no new noise sources will be created on the EMO site.

The machines and equipments – pumps, compressors and turbines are the sources of the noise. The type of the protection of workers against the excessive noise is the provision of IEP (Individual Protection Equipment) - hearing protectors.

No excessive noise was recorded in the EMO surrounding environment. The limits dedicated for the industrial objects and systems valid for the EMO site. Such limits establish the maximal noise level on 80 dB. No dwelling complexes, medicine, recreation or other complexes with limited noise level are in the EMO surrounding environment to the distance of 3 km.

13.2.4.2 Sources of the excessive vibrations

No working places with excessive vibrations over the limits in decree of SR government are in EMO. Even in the frame of operation of EMO, no such working places will be created.

13.2.5 Sources of radiation

The ionising radiation is the main risk factor existing in the nuclear power plant. The mentioned fact valid is not only during the NPP operation, but also after the NPP shutdown until the NPP decommissioning. Main exposition pathways and resulting risks for the population in the surrounding environment are described in the chapter 13.1 “Radiological influence”.

13.2.6 Sources of heat and bad smell

In the reactors of NPP, during the controlled process of the nuclear fuel atoms fission (Uranium enriched with ^{235}U), a heat is produced, which is conducted with help of cooling medium of the primary circuit. This heat us used for the production of the over-heated steam, which drives the turbines for the production of electrical power. Only about 32% of the thermal energy produced in reactor is used for the electrical power production. The remaining thermal energy, not used in the other heat consuming equipments in the equipments and civil structures of NPP, is released into the atmosphere via the cooling tower (or via warmed wastewaters into the recipient) as the waste heat. For this reason, the nuclear power plant could be considered as large thermal "contamination" of the living environment. This source of the thermal "contamination" of the living environment will be doubled during the operation of MO34 NPP. In scientific publication [III.8] is assessed climatic effects of heat and water emissions from cooling towers of NPP. In this paperis proved that termal „contamination" at EMO site (4 units considered) is neglectable in comparison to variablity of local parameters. Maximum change of temperatury is at level of 0,23 °C and this effect is possible only in the close vicinity of cooling towers, which is acceptable.

No bad smells of the special character decreasing the comfort of the working environment will occur in the technology process of NPP and will not occur during the operation of NPP MO34.

13.2.7 Direct and indirect impacts of the MO34 and its operation to the living environment

The complex consideration of the impact of EMO operation to the living environment was done in the several documents concerning the capital investment intents of such NPP. (See e.g. NPP EMO12 power increasing [I.31]). Only those impacts of EMO to the living environment are commented, which will be changed due the mentioned activities, will be commented hereinafter.

13.2.7.1 Impact to the natural components of the living environment

Future operation of NPP MO34 will not impact the contemporary geo-morphological relations and the contemporary situation of the rock formation environment and soil relations on the Mochovce site.

The climatic conditions of the site and the wider region will not be changed due the MO34 operation. The dustiness, noise relations and emissions from the transportation vehicles (and civil construction mechanisms) will be partially increased due the transportation needed for the operation. These changes, with respect to their intensity, will not be significant in the given environment. Similarly, these changes will not be recordable in the wider environment and in the affected villages. The most expressive impact of the MO34 operation will be the contamination of atmosphere with thermal waste from NPP, which will be practically doubled after the start-up. Maximum change of temperatury is at level of 0,23 °C and this effect is possible only in the close vicinity of cooling towers - see chapter 13.2.6.

MO34 operation shall affect neither character or regime ground water At Mochovce site - see Chapter 13.2.2.1.2.

The operation of MO34 will affect neither character nor regime of the underground waters. Groundwater is extracted from two wells owned by SE in Červený Hrádok approximately 8 km away from Mochovce NPP. The maximum permitted take-off is 18 l/s, resp. 15 l/s. After treatment, the groundwater is used for drinking. Up to 2005 groundwater was mostly taken from the two wells in Červený Hrádok, and the remaining part from a substitute source in Kalná nad Hronom (Tab. 13-40). Since 2006, it has been supplied only from the drinking water source in Červený Hrádok. The supply of drinking water from the substitute sources was stopped in June 2005 following the decision of NPP management. In 2008, the volume of pumped groundwater from the source at Červený Hrádok was 126,606 m^3, out of which 116,750 m^3 being effectively supplied to Mochovce NPP. Currently the well at Červený Hrádok provides sufficient drinking water for the Mochovce NPP.

Tab. 13-40 Volume of consumption of drinking water from the different sources in the period 2004-2008

Year	Volume of consumed drinking water (m^3)		
	Wells	Substitute source	Total
2004	353 940	47 167	401 107
2005	178 760	22 305	201 065
2006	96 183	-	96 183
2007	83 478	-	83 478
2008	91 378	-	91 378

The consumption quantity of the utilitarian and cooling water for needs of EMO operation, taken from the Hron River and from the water reservoir Veľké Kozmálovce in 2010 was of 21 012 188 m^3/year, i.e. 0,67 m^3/s. The last mentioned value creates about 1,17% of the long term water flow rate in the water profile Veľké Kozmálovce (51,58 m^3/s). The evaporation, blowing away and flying away creates about 74 – 75% from this quantity (0,45m^3/s) and about 25,64% of water in form of waste water is returned back into the Hron River. Regarding the stored volume of water in the reservoir Veľké Kozmálovce, the water consumption for NF Mochovce will not affect significantly the flow-rate relations of the Hron River. The wastewater from EMO or from the NF Mochovce is released through the waste pipeline into water stream of the Hron River. The volume of such water created in 2010 was 5 426 855 m^3/year (0,17 m^3/s), what makes about 0,3296 % of the total flow rate of the Hron River. The consumption of water and release of the wastewater will not affect the flow rate relations of the Hron River. It results from the mentioned fact that the increasing of the consumption of water and release of the wastewater twice will affect the water regime of the Hron River in non-substantial measure.

Regarding the quality of released water, water taken from the Hron River and waste water are to be treated. Allowed limit concentration in mg/l (except pH and temperature) and balance values in tons/year are established for the releasing of the waste water in individual water quality indicators - Chap.13.2.3.1.

The operation of MO34 on the Mochovce site will not cause the contemporary situation of the flora and fauna, the characteristics of the existing biotopes, protected and infrequent species and biotopes and contemporary migration corridors of animals. Existing genetic fund, the biodiversity and protected areas will not be affected.

The activity of the individual natural components of the living environment will not be changed against the contemporary situation during the MO34 operation. It is supposed that this activity will not be changed significantly even in the future in the consequence of the MO34 operation start-up (with respect to the adopted technical and technology solutions and measures).

13.2.7.2 Impact on the country

The present operation of NPP EMO12 and further operation of MO34 will not cause any change of situation of the country and the villages affected. The relief of the country and relations of the occurrence of individual natural components will not be changed due the proposed activities in the considered area. The realisation of proposed activities will not change similarly the relations between natural components and anthropogenic components of the environment. The functional exploitation of the considered area will remain unchanged. The existing ratio between the forested lands, intensively cultivated agricultural lands and settled area will be conserved. The form of the land use will not be changed. The MO34 operation will not affect the character of the settled area and the character of the regional infrastructure networks. The operation of MO34 will be realised in already erected civil structures and equipments of the EMO site. The general silhouette of the site will be unchanged. The realised activities will not cause an effect of the country view even by any other manner. The territorial system of the ecological stability was in the consequence of the building in the affected area was modified in the past. The NF Mochovce do not affect the ecological situation or; the impact of these facilities to the territorial system of the ecological stability is not demonstrated for the present. Similarly, it is not possible to suppose that the operation of MO34 could cause significant changes in the ecological stability of this territory.

13.2.7.3 Impact to the urban complex and land use

The fundamental changes in the urban complex and in the land use connected with the construction of the NF in Mochovce occurred in the second half of the last Century. The operation of MO34 will not cause any changes in fundamental relations and connections of NF Mochovce to the urban complex. A positive influence will be demonstrated in the improvement of technical, economy and ecological parameters of one from the key equipment from the Slovak power sector. The indirect influence consists also in the maintenance of the certain level of economy and investment activities necessary for conservation of the urban complex and for land use. The operation of MO34 will not have direct impact to the cultural and historical heritage or to archaeological or pale ontological sites of discovery in the site affected by the construction. The operation of MO34 is in accordance with the valid documentation of the territorial planning. The originated potential of the working occasions creates the positive impact for the regional development of the municipalities, the enhanced care of the cultural heritage etc. The operation of MO34 will improve the generation of electricity for production sectors (agriculture, industry, local industry) for transportation, services, recreation and tourist industry. The proposed activities create no demands to generation of connected buildings, activities and infrastructures.

13.2.7.4 Evaluation of the health situation of the population

The health situation of the population in the surrounding environment may be potentially affected by the occurrence of the risk of ionizing radiation caused by the possible release of the radioactive substances to the surrounding living environment. The real data on such risk are in detail described in the chapter 13.1. The activities connected with the MO34 operation of these reactor units itself will not cause any significant increasing of these risk caused before all by the occurrence of radioactive substances in the gaseous and liquid releases from the NF on the EMO site. It is supposed, that the values of released radioactive substances into the living environment will remain under the limits with sufficient reserve.

The limit values of the gaseous and liquid releases from the complex of the NF Mochovce as complex were established so, that the effective dose in the consequence of gaseous and liquid releases to individuals from the critical group of population would not be higher than 0,05 mSv/year [I.6]. The actual values of the radioactivity of nuclides released into the living environment are significantly below the limit. This fact has a consequence that the calculated effective dose values to the critical group of population are negligible in comparison with background effective doses.

13.2.8 Presentation of the non-radiological impacts of EMO to the living environment

For the presentation of non-radiological impacts of Mochovce NPP to the living environment, the report "Complex report on situation in living environment in EMO" is elaborated annually. This report serves to the consideration of Environmental management system by EMO top management and the headquarter of SE,a.s. The report serves also for information of relevant regulatory authorities concerning the living environment. (Regional authority in Nitra, District authority in Levice). The five-years period is considered in each emission of the report. The department of environment SE with co-operation with relevant departments of EMO develop this report. The representative of EMO EMS management submits this report.

The data from such report [I.28] were used for development of the part 13.2 „Non radiological impacts" of this chapter of POSAR.

13.2.9 External monitoring regime of pollutants

Potential risks of pollutant releases into the NPP's environment and subsequent pollution of the surface and groundwater are caused by waste water discharges from the NPP that can contain contaminants used during normal operation of various technological systems of the NPP. Therefore a waste water discharge system will be installed that ensures the monitoring of contaminant content and minimizes the risk of hazardous substance leaks; resp. eliminates the consequences of such leaks.

Waste water from the NPP operation is handled according to its type. It is discharged through the sewer system into the waste water treatment plant and then it is released through a common discharge pipeline into the Hron River. Water from all parts of the sewer systems is discharged through one discharge control point - Drainage facility of EMO. There the level, temperature and chosen chemical parameters of the water are continuously measured and periodically sampled each 24 hours by an automatic sampler. The monitoring is performed in the water measurement station. Analysis of samples in the accredited chemical laboratory of EMO determines the concentration and balance values of pollutants discharged from the NPP. The drain pipeline has a diameter of 1000 mm and it leads into the Hron River with a fall of about 60 meter on its entire length of 5 800 m and is mouthed in the right wall of the dam in Veľké Kozmálovce. Monitoring wells can be found along the pipe, from which samples are taken in order to detect possible leaks. The radionuclide content in the samples is determined by LRKO.

The principles of waste water discharge are defined in Regulation 0PR/4599 "Discharges from various elementary subsystems of EMO" [I.41]. The basic rule for discharges of sewage water into the environment is, that this can be performed only with the knowledge of the shift chemist and technologist and with the approval of the shift engineer and, if active and conditionally active water is discharged, with the consent of the shift foreman of radiation control. Water composition must be checked prior to discharge and results of the water analysis must be known and clearly confirmed.

All waste water, after prior purification or accumulation, is lead into the drain pipe of the Drainage facility of EMO through a network of the following sewage systems:

- Rainwater sewage – water from paved areas of the plant, drainage from roofs, roads in the EMO area, seeping from drains and overflows from technological equipment is mouthed into it. Rainwater is collected by four sewage collectors into two retention tanks with a capacity of 1500 m^3, from which they are after purification drained into the pipe outlets of the EMO Drainage facility. Rainwater from areas where petroleum products are handled, mouths into the industrial oiled sewage. Rainwater from the operational area of MO34 site 11 is collected in three retention tanks with a capacity of 1000 m^3. Oils and petroleum products floating on the surface remain in the tanks. These tanks are drained into the Telinsky stream through a siphon on the drain channel.

- Sanitary sewage - water from toilets, sanitary loops, from the kitchen and from special laundry is mouthed into it. Water with higher levels of surfactants and radioactive materials is lead from the purification station to the sewage treatment plant. After purification it is lead to the mechanical and biological treatment plant. Sewage water from the operational premises of MO34 site 11 has a common sewage system, which is running into the central biological wastewater treatment plant. Purified water is released into the Telinsky stream after a three stage treatment.
- Industrial oiled sewage – handles water from premises in which oil or petroleum products are handled and there is a high probability of its pollution by petroleum products. This water is treated in a gravitational oil separator and in the second stage by alkaline clarification in the oiled water treatment plant. Purified water is not discharged, but is used as an additional source of raw water.
- Special industrial (technological) sewage – collects waste water from various technological processes. Aggressive water from machinery and chemical plants is lead to the neutralization station. There it is purified and then discharged into the industrial sewage. Purification of radioactive water is performed by filtration and ion exchange, in this way low-level radioactive water containing tritium is generated. Active water is after filling the control tank and after a radiochemical check, and at least a 30 fold dilution, pumped into the special sewage. Waste water from the chemical water treatment, treatment of turbine condensate and from the steam generator blowdown is drained into the neutralizing tank and after neutralization it is discharged into the industrial sewage system. If the volume activity limit is exceeded, it is lead back into the special purification of radioactive water.

The sampling schedule for pollutant detection from individual facilities, including the frequency of sampling, monitored pollution parameters (indicators) and threshold values for these parameters is defined in Regulation 0TH/4621 "Schedule of sampling in auxiliary systems and water" [I.43].

The quality of waste water is monitored by the relevant staff through sensory and visual inspection (color, odor of water, fatty coating, foam formation, occurrence of dead fish on the surface and below etc.).

In samples from individual facilities the values for individual indicators are determined according to the expected occurrence of pollutants stemming from the facility. Pollution control and waste water treatment is carried out according to the analytical process [I.44] and [I.45]. Permitted indicator values are defined in [I.46].

Tab. 13-41 Sampling and measurement schedule with indicated pollutant thresholds at the EMO Drainage facility [I.43]

Parameter	Unit	Concentration values „p“	Sampling frequency		Method of measurement
			Not functional continual measurement	Functional continual measurement	
pH	-	6.0 – 9.0	1 x D*	1 x W**	CHEMLAB (parameters are determined from sample analysis performed in the laboratory)
$CHSK_{Cr}$	mg/l	≤ 35.0	5 x W**	1 x W**	
$N – NH_4^{+a)}$	mg/l	$\leq 1.5^{c)}$	5 x W**	1 x W**	
ammonia NH_4^+	mg/l	≤ 1.92	5 x W**	1 x W**	
sulfate SO_4^{2-}	mg/l	≤ 690.0	5 x W**	1 x W**	
$N – NO_3^{-\ a)}$	mg/l	$\leq 16.0^{d)}$	5 x W**	1 x W**	
nitrate NO_3^-	mg/l	≤ 70.9	5 x W**	1 x W**	
conductibility	μS/cm	N/A	1 x W**		

Parameter	Unit	Concentration values „p“	Sampling frequency		Method of measurement
			Not functional continual measurement	Functional continual measurement	
NL	mg/l	≤ 40.0	1 x W**		
RL_{550}	mg/l	≤ 1 000.0	1 x W**		
RL_{105}	mg/l	≤ 1 500.0	1 x W**		
chloride Cl^-	mg/l	≤ 100.0	1 x W**		
P_{tot} [a)]	mg/l	≤ 1.0	1 x W**		
Phosphate tot.	mg/l	-	1 x W**		
NEL [b),e),f)]	mg/l	≤ 0.5	1 x W***		
temperature °C [b)]	°C	≤ 30.0	1 x W***		
BSK_5	mgO_2/l	≤ 12.0	1 x 2M**		
hydrazine N_2H4	mg/l	≤ 0.5	1 x 2M***		
AOX	mg/l	≤ 0.2	1 x 3M***		
active chlorine [b)]	mg/l	≤ 0.1	1 x 3M***		
pH	-	6.0 – 9.0	*Reading 1xZ*		SEZ LOV (parameters determined by continual measurement)
$CHSK_{Cr}$	mg/l	≤ 35.0	*Reading 1xZ*		
$N - NH_4^{+}$ [a)]	mg/l	≤ 1.5 [c)]	*Reading 1xZ*		
sulfate SO_4^{2-}	mg/l	≤ 690.0	*Reading 1xZ*		
$N - NO_3^{-}$ [a)]	mg/l	≤ 16.0 [d)]	*Reading 1xZ*		
Conductibility	µS/cm	N/A	*Reading 1xZ*		
Flow	m^3/h	N/A	*Reading 1xZ*		

Note:

- 1xW**, 1x2M**, 1x2M***, 1x3M*** "p" – 24-hour decanted sample collected by dosimetry personnel with a continual sampling device – recorded into 0GMA0102
- 1xD*, 5xW**, "p" – 24-hour decanted sample collected by dosimetry personnel with a continual sampling device – recorded into 0GMA0101
- 1xW***, 1x2M***,1x3M*** – point sample collected by personnel of the chemistry department with a mobile sampling device in shaft $S\text{-}S_2$ – recorded into 0GMA0102
- a) These parameters are determined by calculation from the measured values of ammonia, nitrates and phosphates,
- b) These parameters are determined in the point sample, which is taken before and after decanting of the 24-hour samples and is recorded into 0GMA0102, the specific date is given in the Sampling schedule of decanted and point samples of EMO
- c) at the time of neutralization tank discharge the concentration value may be ≤ 3.0 mg/l
- d) which may be exceeded five times a year up to a concentration of 22.0 mg/l
- e) for the duration of TGO or RGO the sampling frequency is increased to 1xD (samples from weekends and holidays are deferred and analyzed on the next working day after collection)
- f) the NEL parameter measured separately, outside of the Sampling schedule of decanted and point samples of EMO shall be analyzed in the point sample taken after decanting of the 24-hour sample
- specific date of the decanted samples is given in the Sampling schedule of the decanted samples
- If the parameters of continual measurement are exceeded, this parameter is measured in a 24-hour decanted sample taken by the dosimetry personnel with the continuous sampling device at the time the parameter was exceeded
- Thresholds are listed in the Decree of the Regional Authority in Nitra, Department of Environment no. 2007/00029 and 2010/00729

- Values of continuous measurements, which are recorded by ZEZ LOV, are electronically transferred by TCHR to CHEMIS at least 1xW – recorded into 0GMA0101
- (p) – concentration limits of pollution for the relevant indicator in the decanted sample for a given period of time

Abbreviations:

$CHSK_{Cr}$ - chemical consumption of oxygen

BSK_5 - biological consumption of oxygen

NEL - non polar extractable materials

RL_{105} - dry residue after drying at 105°C

RL_{550} - dry residue after drying at 550°C

$P_{tot.}$ - Total Phosphorus

NL - insoluble materials

AOX - adsorbing organic compounds bonded to halogens

Tab. 13-42 Pollutant indicator thresholds for the discharge of waste water into the Telinsky stream valid for the Waste water treatment station of MO34 [I.47]

Parameter	Concentration [mg/l]	Balance values [t/year]
BSK_5	8	0,88
$CHSK_{cr}$	40	4,4
NL	20	2,2
$N\text{-}NH_4^+$	5	0,55

Note:

- Samples for analysis are taken at the discharge facility
- Concentration is measured from a 2-hour sample 4x annually

Tab. 13-43 Sampling schedule – sensors below the dam of sludge bed at Čifáre [I.43]

Parameter	Unit	Normalized value	Sampling frequency
pH	-	Not normalized	2 x **Y ***
chloride Cl^-	mg/l	Not normalized	2 x **Y ***
sulfates SO_4^{2-}	mg/l	Not normalized	2 x **Y ***
Iron	mg/l	Not normalized	2 x **Y ***
$CHSK_{Mn}$	mgO_2/l	Not normalized	2 x **Y ***
calcium Ca	mg/l	Not normalized	2 x **Y ***
Conductibility	μS/cm	Not normalized	2 x **Y ***
ammonia NH_4^+	mg/l	Not normalized	2 x **Y ***
Calculated water hardness	mmol/l	Not normalized	2 x **Y ***
NEL	mg/l	Not normalized	2 x **Y ***

Note:

- 2 x Y: April, November
- The operator of the facility shall provide the conditions for appropriate (representative) sampling
- Specific date of decanted samples are listed in the Sampling schedule of decanted samples
- Parameters and frequency of sampling is determined by 0PO/4002 Monitoring of the state of the sludge bed dam

Tab. 13-44 Sampling schedule – discharge of waste water from the sludge bed to the Telinsky stream [I.43]

Parameter	Unit	Normalized value	Sampling frequency
pH	-	6.0 – 8,7	6 x Y
NL	mg/l	≤ 20.0	6 x Y
N-NH4+ a)	mg/l	≤ 0,50	6 x Y
ammonia NH4+	mg/l	≤ 0,65	6 x Y
Soluble material RL105	mg/l	≤ 2 000.0	6 x Y

a) This parameter is determined by calculation from the values for ammonia

Tab. 13-45 Sampling schedule – sampling from wells along the waste water pipe leading to the Hron River [I.43]

Parameter	Unit	Normalized value	Sampling frequency
Chlorine Cl^-	mg/l	not norm.	2 x Y
Phosphates, total	mg/l	not norm.	2 x Y
$CHSK_{Cr}$	mgO_2/l	not norm.	2 x Y
Sulfates SO_4^{2-}	mg/l	not norm.	2 x Y
Soluble material RL	mg/l	not norm.	2 x Y

Note:

- The samples are brought into the CHEM.LAB by the employees of outer dosimetry
- The date is listed in the sampling schedule of decanted samples

Tab. 13-46 Sampling schedule for the Hron River [I.43]

Parameter	Unit	Normalized value	Sampling frequency
pH	-	6 – 8.5	6 x **Y** *
TOC	mg/l	Not normalized	6 x **Y** *
$CHSK_{Cr}$	mgO_2/l	< 35.0	6 x **Y** *
NL	mg/kg	Not normalized	6 x **Y** *
chlorine Cl^-	mg/l	< 200	6 x **Y** *
sulfates SO_4^{2-}	mg/l	< 250	6 x **Y** *
$N – NH_4^+$	mg/l	<1.0	6 x **Y** *
ammonia NH_4^+	mg/l	< 1.3	6 x **Y** *
$N – NO_3^-$	mg/l	< 5.0	6 x **Y** *
nitrates NO_3^-	mg/l	< 22.1	6 x **Y** *
Phosphorus, total $P_{tot.}$	mg/l	0.40	6 x **Y** *
RL_{550}	mg/l	< 640.0	6 x **Y** *
RL_{105}	mg/l	< 900.0	6 x **Y** *
hydrazine N_2H4	mg/l	Not normalized	6 x **Y** *
NEL	mg/l	< 0.1	6 x **Y** *
BSK_5	mgO_2/l	< 7.0	6 x **Y** *
AOX	mg/l	< 0.02	6 x **Y** *
active chlorine	mg/l	< 0.02	6 x **Y** *

Note:
* Samples are usually taken in the following months: February, April, June, August, October and December. If the sample is brought in by the employees of the Slovak Water Management Company – Hron basin, the analysis is performed separately.

Groundwater Monitoring

A comprehensive national hydrogeological groundwater monitoring program at the Mochovce site currently does not exist. Groundwater monitoring is ensured through a one-off ad hoc ordering of specified data from specialized institutions (eg. EKOSUR).

Furthermore, monitoring of drinking and groundwater is carried out in order to determine eventual contamination of groundwater caused by direct leaching of radioactive materials into different depths and distances in the bedrock. Groundwater levels in individual wells of the RÚ RAO site are monitored since 2000. Measurements are carried out by JAVYS, a.s. Bratislava. Sampling is carried out weekly, biweekly, monthly and quarterly. For further information, see Section 13.1 and chap. 04.10 [I.50].

Quantitative monitoring of groundwater in the area around the NPP was carried out in the period between 2011 – 2010 at 19 facilities. Parameters monitored included the water level in centimeters below the sampling point at all 19 facilities and the temperature of groundwater at selected eight monitored facilities. At 9 of the monitored facilities the groundwater level is measured daily, while at the remaining 10 facilities it is measured weekly. For more details see chapter 04.06 [I.51].

Monitoring of surface waters on the national level

The Monitoring of surface waters is carried out on the national level through the Slovak Hydrometeorological Institute (SHMÚ) and the Slovak Water Management Company (SVP). SHMÚ monitors the quantitative and qualitative indicators of surface waters. The monitoring consists from the observation, measurement and evaluation of water levels and flow regimes of surface waters through a network of surface water gauging stations, with regard to extreme flows. In the basin of the Hron river 51 gauging stations of SHMÚ are installed, including 11 directly on the Hron river. Of these nine are above Veľké Kozmálovce, the others are further downstream. One is in Kalná nad Hronom and one near the mouth of the Hron river (Kamenín). The Slovak Water Management Company (SVP) provides care for the rivers and maintains the property built on them, cares for the quantity and quality of surface and groundwater, provides flood protection and ensures that the navigational conditions on the rivers are maintained. For monitoring it uses its own gauging stations, as well as data from the gauging stations of SHMÚ. In terms of EMO operation, the most important station is at the dam near Veľké Kozmálovce (flow and water level measurement). More detailed information on the national monitoring programs is listed in section 4.10 [I.50].

Monitoring during emergency situations

The ways to address emergency situations associated with exceeding the thresholds of any indicator of pollution at the various facilities are described in [I.41]. On all waste water systems such technical measures are implemented that allow them to receive additional technical measures for addressing virtually all emergency situations that could be caused by leakage of pollutants into the recipient.

Minimizing the risk of contamination of waste water is ensured through a system of hazardous and selected hazardous substance storage. All facilities for the storage of such materials are built in accordance with STN752415 and are provided with containment barriers. Leak tests are carried out on them regularly.

The properties and quantities of hazardous and selected hazardous substances, their distribution, and maximum allowed storage capacity and maximum retain volumes are given in [I.47].

For the purpose of determining the organization of responsibilities and procedures for dealing with emergencies, that could jeopardize and/or cause the deterioration in the quality of surface and groundwater in Mochovce an "Action plan for emergencies and pollution of surface and groundwater for the Mochovce area" 0-PLN/0003 was elaborated [I.47], which was approved by the Slovak Environmental Inspection [I.48].

Based on monitoring of indicators of water pollution two levels of emergencies are introduced:

- I. level emergency: exceeding of the threshold values of pollution for one or more indicators,
- II. level emergency: Extraordinary deterioration of water quality or extraordinary threat to water quality caused by waste water discharges breach any limits, or caused by uncontrollable leakage of hazardous substances. When dangerous substances are spilt during transport (oil, chemicals) and during spills of dangerous substances outside of the retention areas, it is always considered as a II. level emergency.

The category of the emergency is determined at the drainage facility in the retention and measurement shaft. Samples are taken from the retention tanks, from the outlet of the waste water treatment plant and the shafts of the individual sewer systems. During II. level emergencies also the sensory properties at the point of discharge into the Hron river, resp. Telinský stream are monitored. The seriousness of an emergency is determined by the shift engineer based on the report about the exceeding of threshold values of pollutant concentration elaborated by the chemistry technologist.

Sampling during emergencies associated with leakage of pollutants from the facility is performed at the following sampling sites:

- Drainage facility for EMO12,
- For MO34 the sampling points are:
  - Drainage facility at the Telinsky stream
  - the rainwater pumping station at site B
- Sampling points may also be determined according to the need to clarify the cause of the hazardous substance leakage.

Samples are taken at a frequency of three hours or as directed by the head of the coordination group. The shift engineer on the basis of results of sample analyses assesses the extent of the emergency, issue orders to identify the causes and to implement appropriate technological measures in order to avert or completely eliminate the effects of such an emergency.

The coordination group has developed procedures for the elimination of consequences of emergencies, depending on the point of leakage and the occurrence of hazardous substances. These procedures are part of [I.47]. Material and equipment for the disposal of an accident is available in the emergency storage. Emergency storage for MO34 is located in the area of the waste water treatment plant, in the sewage pumping station building.

Leakage that exceeds 5% of the threshold quantity of hazardous or selected hazardous substances and threatens the surface and groundwater quality is considered as a major industrial accident (ZPH) and is discussed in the "Plan of measures for the solution in case of ZPH" 0-PLN/0004 [I.49]. Particularly excessive emissions, fires or explosions involving one or more selected hazardous substances stemming from uncontrolled developments in operation, which lead directly or results in serious damages or threat to life, health, environment or property within or outside the plant premises are considered as a major industrial accident is.

For the purposes of emergency response and training of staff to deal with the consequences of major industrial accidents, representative emergency scenarios were developed which included the results of the potential effects of major industrial accidents (leakage, fires, explosions and their combination), determined by modelling. These scenarios were developed with regard to the actual processed volumes of selected hazardous substances. For each identified scenario its frequency was determined and its impact was analyzed, thus the extent and severity of potential major industrial accidents was assessed. Individual representative emergency scenarios are described in [I.49].

13.2.10 Notification system necessary for intervention against unexpected leakages

Every employee must notify his immediate superior or shift engineer of any disorders associated with the possible release of hazardous substances or about a leak that can:

- Cause the exceeding of the threshold values for indicators of waste water,
- Endanger the quality of surface water or groundwater.

The chemistry technologist informs the shift engineer:

- about the exceeding of the threshold values of discharges,
- the changes in the sensory properties, especially changes in color, odor and foaming of water taken from the discharge facility,
- Writes a report about his findings regarding the exceeding of the threshold values of pollutants in the discharge facility, which is the basis for dealing with emergencies,
- The report is closed only after the reasons for the exceeding of the threshold values are established and after the adoption of effective countermeasures.

This report contains information on the date, time and the method by which the leak was detected, values of pollutant concentrations, description and estimated causes, the name and position of the employee who found the leak and of the employee to whom he reported the leakage. The report also contains information on the evaluation of the event; source of the leakage and proposed measures to eliminate the pollution source, the name and position of the employee devising the measures and of the employee responsible for implementing these measures, the name of the head of the coordination group, head of the environment department and of the department of chemical control.

In general, the algorithm of reporting an event is as follows: An employee who detected a leak of a hazardous substance or an employee of the chemistry department who detected during a regular chemical analysis that a value of a pollution indicator has been exceeded, notifies about the event the shift engineer (ZI) and the firefighting unit (ZHÚ). The ZI notifies about the event the maintenance of the particular facility and sends the firefighting unit to investigate the event. He also takes measures in order to find the cause and source of the leak. If the maintenance and firefighting unit intervention was successful, the head of operation sends a record of the event to the ecologist. If the intervention of the maintenance and the fire fighters was not successful, the ZI or the ZHÚ calls the ecologist at standby, who shall, after an assessment call together the coordination group (the head of the coordination group is the ecologist at standby). If the intervention was successful and the thresholds values were not exceeded, a record about the event is made. If the intervention was not successful and the thresholds values were exceeded in the discharge facility, the coordination group shall ensure that appropriate corrective actions are taken. In the event that there are also signs of extraordinary deterioration of water quality, the ecologist at standby prepares a report about the ecological accident. This report is then forwarded by the ecologist or the head of the environmental department to the Slovak Environment Inspectorate in Nitra, Slovak Water Management Enterprise at Banská Bystrica (Hron basin) and Piešťany (Váh basin). The head of the environmental department will then adopt measures in order to eliminate the consequences of the accident. The scheme of the algorithm of event notification according to [I.47] is shown on Fig. 13-16 .

In accordance with [II.15] and [I.49] the written report is sent to the Ministry of Environment of the Slovak Republic also in the event of any major industrial accidents, which are associated with fire, explosions and accidental discharges of a dangerous substance in an amount greater than 5% of the threshold value if it has at least one of the following consequences:

- a person's death or the injury of at least six persons in the area of the plant and their following hospitalization for at least 24 hours or injury of at least one person outside of the plant and its hospitalization for at least 24 hours, or damage to at least one dwelling outside of the plant, which due to the accident became permanently uninhabitable or the need for evacuation and sheltering of persons for more than two hours, if the total product (persons x hours) is at least 500 or interruption of drinking water, electricity, gas supply or telephone services for more than two hours, if the total product (number of people x hours) is at least 1000.
- Immediate damage to the environment: permanent or long-term damage to terrestrial habitats of protected species and protected areas covering an area of at least 0.5 ha of continuous habitat and 10 ha in the case of dispersed habitats; severe or permanent damage to freshwater habitats with an area of at least 10 km along a river or channel, 1 ha lake, pond or water reservoir; serious damage or pollution of aquifers or groundwater of at least 1 ha.
- Damage to property on the territory of the plant is at least 2 987 452.70 € or outside of the plant is at least 746 863.18 €.
- Accident with transnational effects in another country.

The written report of major industrial accidents has to be sent to the Ministry of Environment and in accordance with [II.15] also to the European Commission.

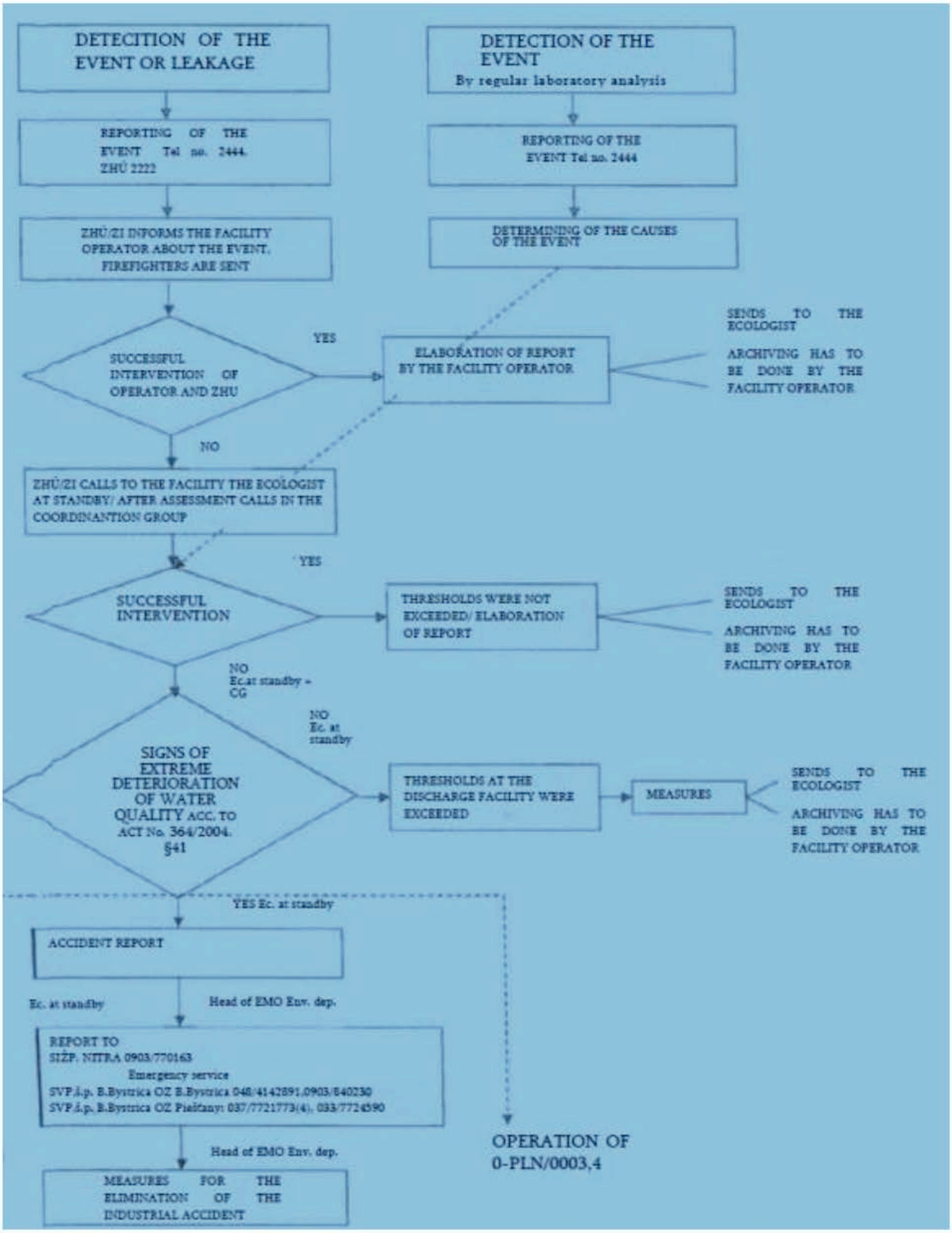

Fig. 13-16 Algorithm for the reporting of accidents

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Annex 1 Limit values of the releases from individual NF on sites Jaslovské Bohunice and Mochovce, [Bq/year]

Type (group) of releases	Jaslovské Bohunice site					Mochovce site			
	JAVYS			SE-EBO	Total	SE-EMO	JAVYS		Total
	JE A-1 [(1)]	MSVP	EBO12	EBO34		EMO12	FS KRAO	RÚ RAO	
ATMOSPHERE									
Radioactive noble gases			$2,0.10^{15}$	$2,0.10^{15}$	$4,0.10^{15}$	$4,1.10^{15}$			$4,10.10^{15}$
Long living airborne particulates	$9,4.10^{8}$	$3,0.10^{8}$	$7,94.10^{10}$	$7,94.10^{10}$	$1,6.10^{11}$	$1,7.10^{11}$	$8,0.10^{7}$		$1,70.10^{11}$
Alpha particulates	$8,8.10^{6}$		$2,06.10^{7}$	$2,06.10^{7}$	$5,0.10^{7}$		$1,0.10^{6}$		$1,00.10^{6}$
Strontium $^{89,90}Sr$	$2,8.10^{7}$		$1,36.10^{8}$	$1,36.10^{8}$	$3,0.10^{8}$		$2,0.10^{6}$		$2,00.10^{6}$
Iodine (^{131}I)			$6,5.10^{10}$	$6,5.10^{10}$	$1,3.10^{11}$	$6,7.10^{10}$			$6,70.10^{10}$
HYDROSPHERE [(2)]									
Recipient the Váh River						Recipient the Hron River			
Tritium	$3,7.10^{12}$		$2,0.10^{13}$	$2,0.10^{13}$	$4,37.10^{13}$	$1,2.10^{13}$	$3,0.10^{11}$		$1,23.10^{13}$
Other radionuclides (except tritium)	$1,2.10^{10}$		$1,3.10^{10}$	$1,3.10^{10}$	$3,8.10^{10}$	$1,1.10^{9}$	$3,9.10^{9}$		$5,00.10^{9}$
Recipient the Dudváh River						Recipient Čifársky pond			
Tritium	$3,7.10^{10}$		$2,0.10^{11}$	$2,0.10^{11}$	$4,37.10^{11}$			$1,9.10^{10}$	$1,9.10^{10}$
Other radionuclides (except tritium)	$1,2.10^{8}$		$1,3.10^{8}$	$1,3.10^{8}$	$3,8.10^{8}$			$2,9.10^{8}$	$2,90.10^{8}$

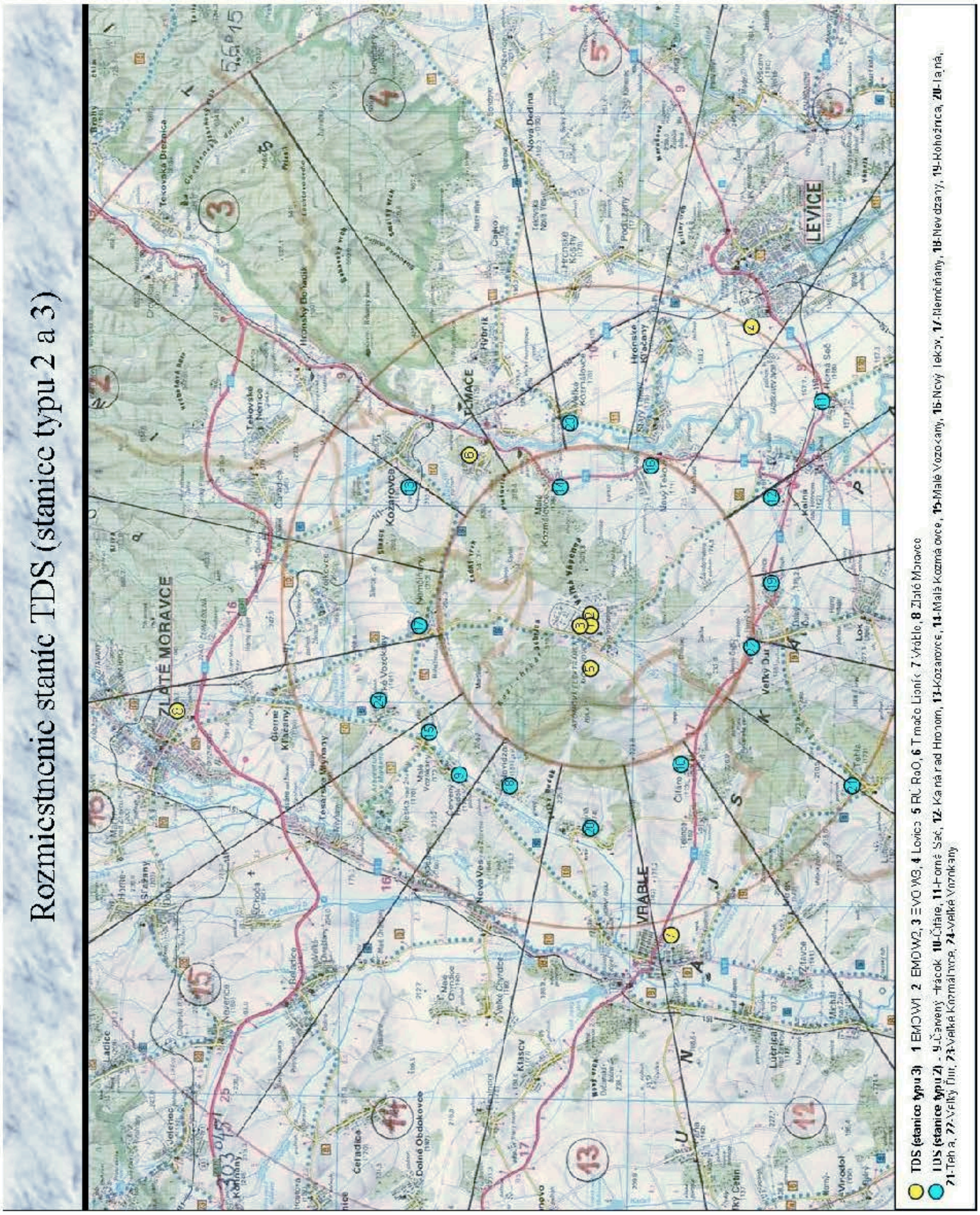
(1) The limits for ventilation stack of the "Bohunice waste processing centre" are included into limit for ventilation stack of A-1 and create 10% of this value..

(2) For the volume activity of radionuclides in the wastewater (concentration limit) valid the limit of $1,0.10^{8}$ Bq/m^{3} for Tritium and 40.10^{3} Bq/m^{3} for corrosion and fission products for all recipients.

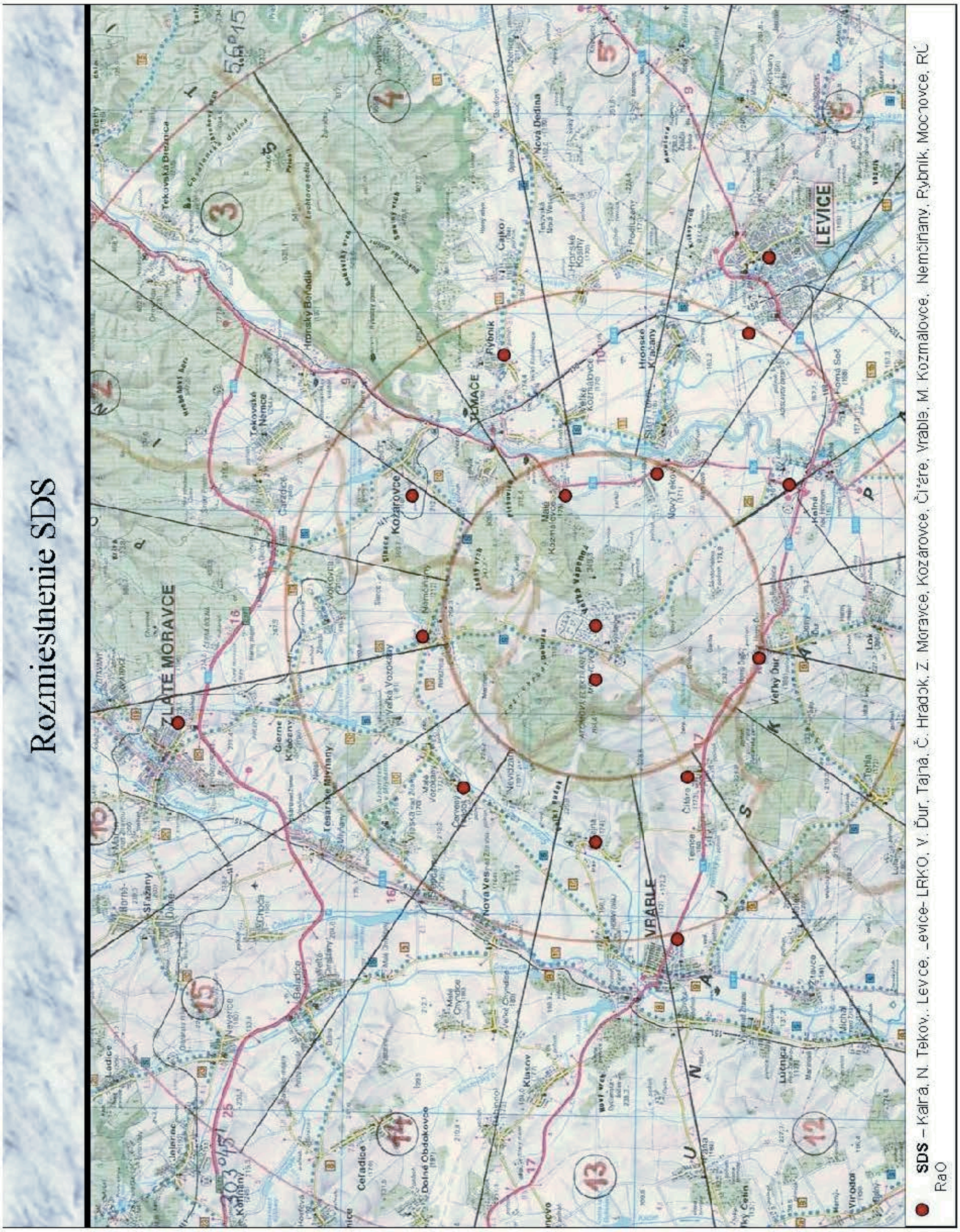
Annex 2 **Real values of releases from individual NF on sites Jaslovské Bohunice and Mochovce (Averages in years 1999 to 2002), [Bq/year / %]**

Type (group) of releases	Jaslovské Bohunice site					Mochovce site	
	JAVYS			SE-EBO	Total	SE-EMO	JAVYS
	JE A-1	MSVP	EBO12	EBO34		EMO12	RÚ RAO
ATMOSPHERE							
Radioactive noble gases / % from the limit			$1,4.10^{13}$	$8,14.10^{12}$	$2,22.10^{13}$ / 0,55	$1,28.10^{13}$ / 0,31	
Long living airborne particulates / % from the limit	$2,23.10^{7}$	$2,88.10^{7}$	$3,07.10^{8}$	$9,46.10^{6}$	$3,26.10^{8}$ / 0,20	$1,53.10^{7}$ /0,009	
Iodine (^{131}I) / % from the limit			$9,57.10^{8}$	$2,03.10^{7}$	$9,77.10^{8}$ / 0,75	$4,87.10^{7}$ / 0,073	
HYDROSPHERE							
Recipient the Váh River						Recipient the Hron River	
Tritium	$1,37.10^{12}$		$6,12.10^{12}$	$7,57.10^{12}$	$1,48.10^{13}$ /33,8	$8,66.10^{12}$ / 72,15	
Other radionuclides (except tritium)	$1,04.10^{8}$		$5,92.10^{7}$	$2,63.10^{7}$	$1,89.10^{8}$ / 0,50	$5,76.10^{7}$ / 5,23	
Recipient the Dudváh River						Recipient Čifársky pond	
Tritium	$9,24.10^{5}$				$9,24.10^{5}$ / 0,0002		$6,27.10^{6}$ / 0,03
Other radionuclides (except tritium)	$3,16.10^{5}$				$3,16.10^{5}$ / 0,08		$1,36.10^{6}$ / 0,47

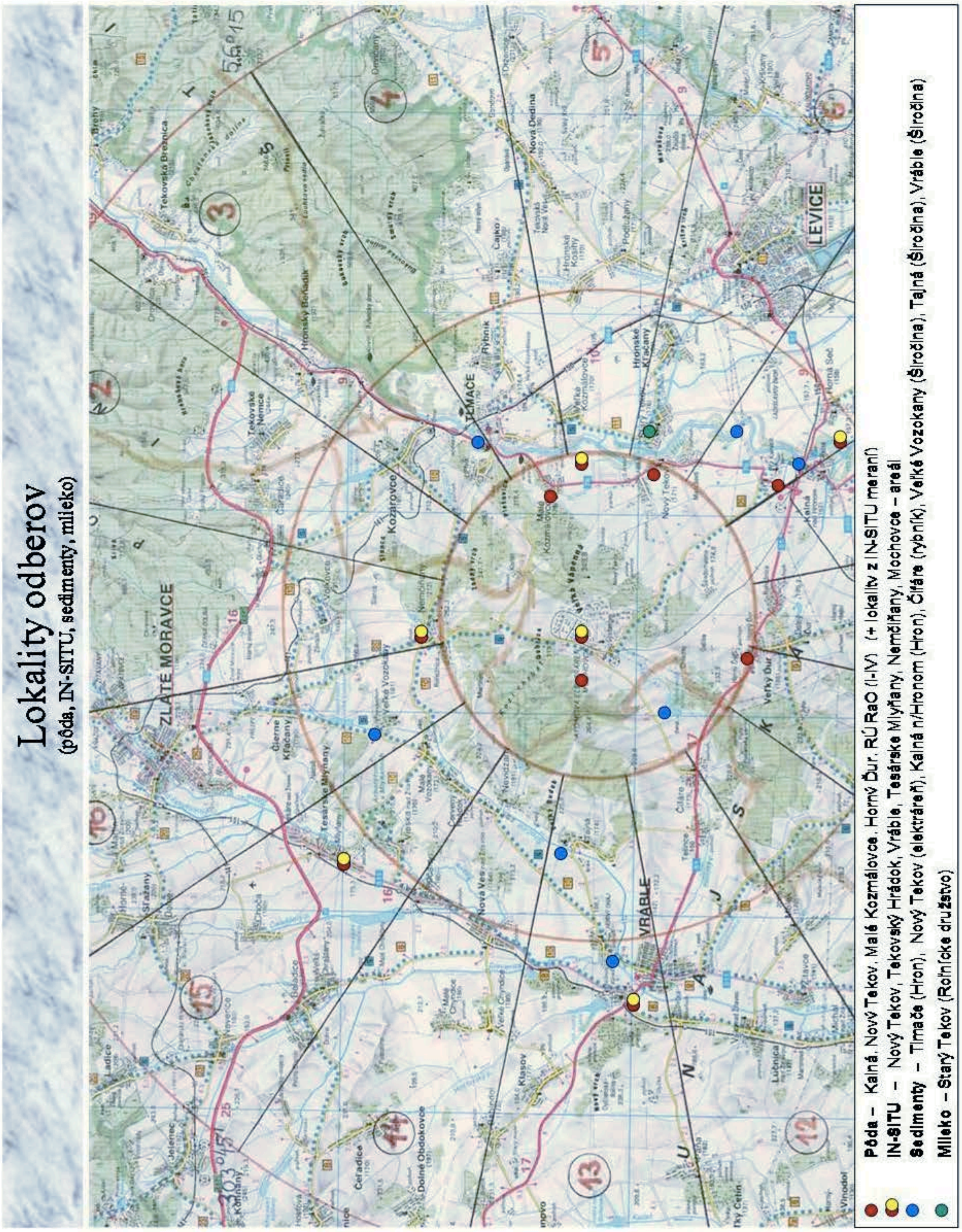
Annex 3 Positions of TDS



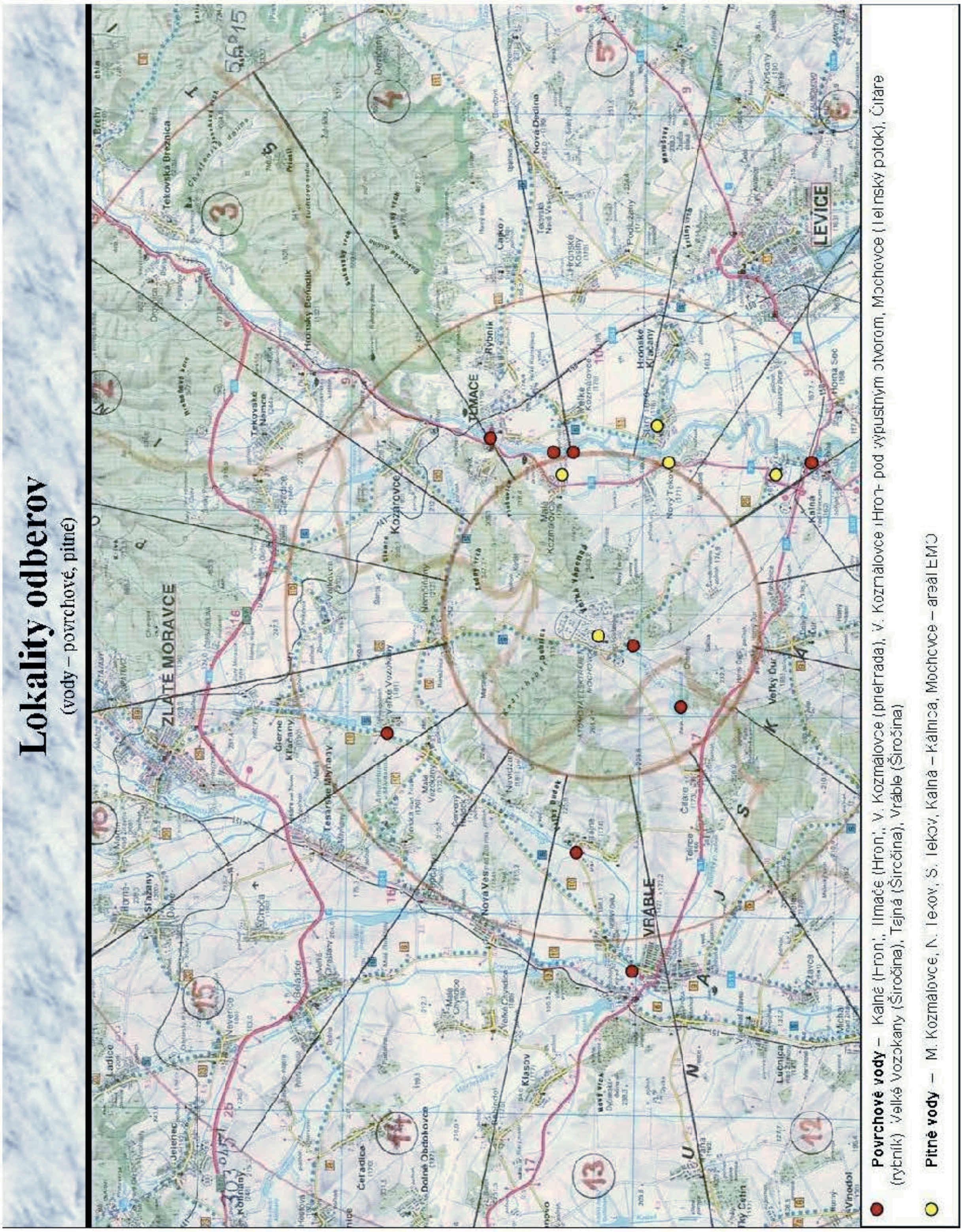
Annex 4 Positions of SDS



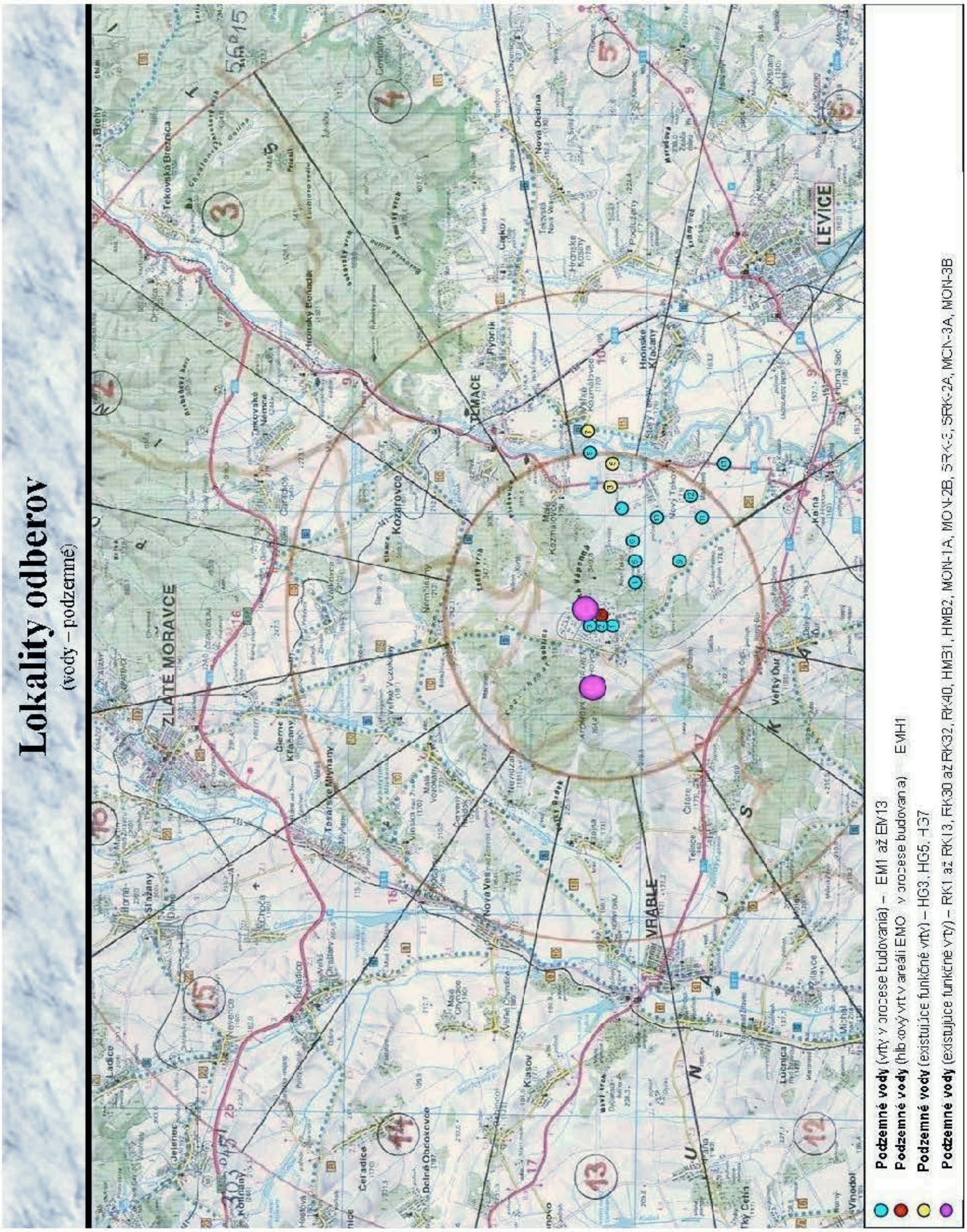
Annex 5 Sampling places (soil insitu - milk)



Annex 6 Sampling places (water–surface drinking)



Annex 7 Sampling places (water–underground)



Annex 8 Sampling places (TLD)